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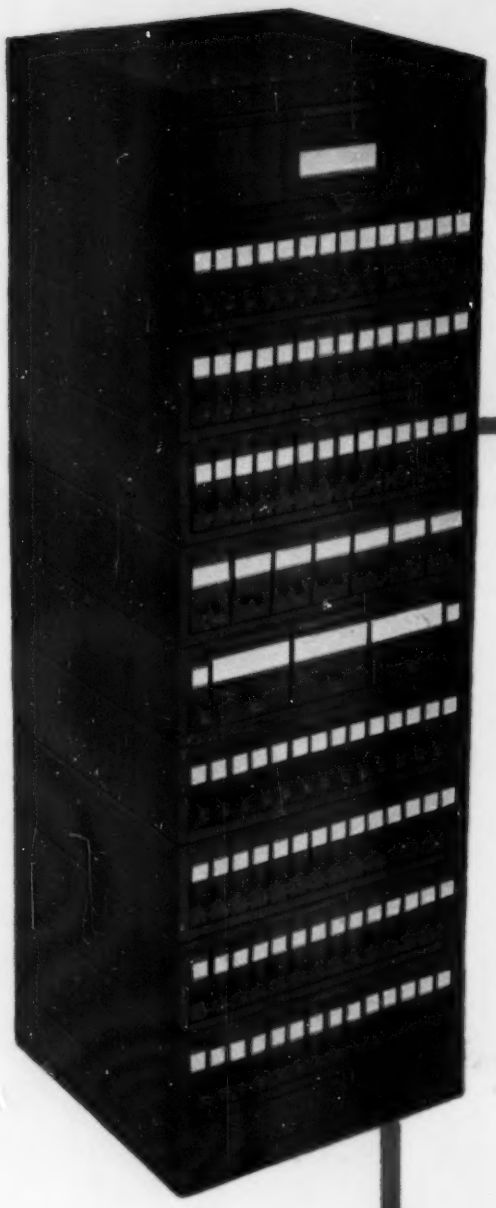
Science

Crested Penguins of the Snares Islands

(See page 463)



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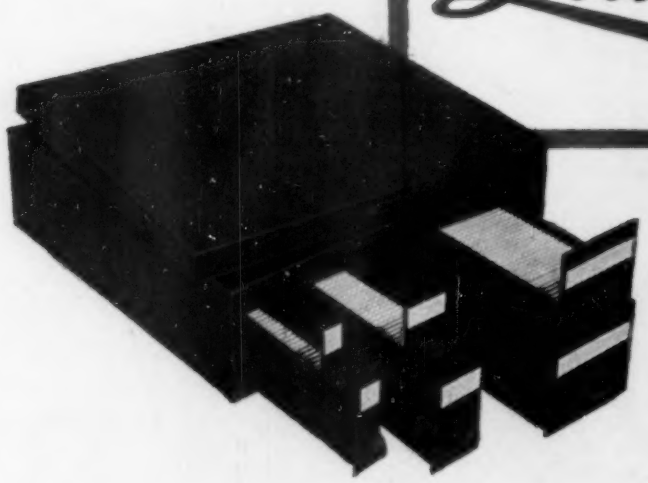

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Recent Advances in the Study of the Crystalline State

Sir Lawrence Bragg, O.B.E., F.R.S.

IT IS NATURAL FOR ME TO CHOOSE as the subject of my address the field of X-ray analysis of crystals, in which I have always worked. The accidents which determine the nature of any man's scientific investigations have always interested me. A main factor in my own case was my father's interest in the nature of X-rays, because he so often discussed with me the significance of Laue's discovery of X-ray diffraction in the summer vacation of 1912. I doubt, however, whether this would have been more than a passing interest of mine had it not been for some contributory factors during my time as a student at Cambridge. Our lecture courses at that period only partly covered the field of physics, going intensely into some branches and leaving others quite untouched; they were very different from the conscientious reviews of the whole subject represented by Honors courses in universities today. They did, however, leave us a good deal of time for reading, which I know I pursued in a very desultory and haphazard way. But one course particularly fired my imagination, the course on Optics given by C. T. R. Wilson. It was not a very easy course to follow, because the blackboard often heard a good deal more of the lecture than we students did, but his way of thinking about optical problems had the qualities of style and grace. It was like being shown how to produce a stroke by a master of a game; he taught us the technique of scientific thinking. He was also in charge of the practical classes. Like all young students, I was keen to 'finish' an experiment and go on to the next. C. T. R. was too gentle and kindly ever to suggest we might be wrong or had skimped our work, but by a series of apologetic and hesitant comments we were somehow made to feel that there was a great deal more to it and that we had better try all over again. I would like to take this opportunity of paying tribute to one whose teaching must have profoundly influenced, directly or indirectly, the physics courses in most of the universities in this country, for many who are now in responsible positions have been his pupils. He gave me a love for physical optics which was a major influence in deciding me to research in X-ray optics. Another factor, which illustrates the part chance plays in deciding one's line, was a particular meeting of a very small and informal society in Trinity formed to discuss scientific papers. The subject of one of these papers was the Pope-Barlow theory of valency-volume, according to which atoms packed together as if they were spheres with a volume proportional to their valency. The theory was wrong, but our talk occurred at about the time Laue's discovery was made, and it made me think about the geometrical ways in which atoms could pack together in the solid state. Nowadays most scientists have some acquaintance with the three-dimensional geometry of crystalline arrangement, because so much light has been cast on physical and chemical problems by the success of crystal analysis. At that time, hardly anybody except a few isolated enthusiasts had given it a thought. Barlow was one of these enthusiasts. His pictures of close-packed atoms were a fertile source of inspiration and just supplied the missing link in understanding the optics of X-ray diffraction. It has always been a lesson to me in the value to young students of small scientific societies where they themselves give the papers, especially when they spread themselves over a wide field. Science is so rich and unexpected in its surprises that one never knows what odd bit of information may supply the necessary clue to the solution of a problem. I wonder sometimes if we are not too efficient nowadays in planning well-rounded and comprehensive courses which demand all of our students' time and energy, leaving them little opportunity to browse in less specialized regions. In my case, at any rate, it was this interest in Barlow's geometrical constructions which led me to seek a new interpretation of Laue's diffraction pictures, and so to the idea that they revealed the arrangement of the atoms in crystals.

Sir Edward Appleton recently asked me to quote some examples of new achievements in science and technology which have been the direct result of X-ray analysis. I confess that I found it a hard question to answer. In the case of such discoveries as that of the electron by J. J. Thomson, or the nature of the nucleus and its disintegration by Rutherford, one can at once point to a new physics and a new technology which has been or will be made possible by them. The analysis of the arrangement of matter by X-rays has had a far-reaching influence, but one of another and less direct kind. No new fundamental particle has been revealed by the X-ray microscope. The in-

From the address delivered by the president of Section A (Physics and Mathematics) of the British Association for the Advancement of Science on September 10, during the Association's meeting at Brighton.

formation it has provided has been of a type which one might have predicted in a vague and uncertain way. What it has done has been to replace guesses by accurate and precise knowledge of atomic architecture in matter, and this has led to its having a profound influence on all the physical sciences. It may well in the near future have an equally great influence on the biological sciences. I count myself fortunate in that my subject has been one which has taken me into so many fields and involved collaboration with colleagues in so many branches of science. Mineralogy, inorganic chemistry, organic chemistry, metal chemistry, metal physics, colloid chemistry, biochemistry—X-ray analysis has had as close a connection with these sciences as it has with experimental and theoretical physics. In each case former ideas have been modified and clarified, and new lines have been opened up, by our now being able to see the precise way the atoms are related to each other in space.

In my own subject of physics there is a parting of the ways at the present time. The main principles of atomic structure, the great puzzle in the early years of this century, have been discovered. Though the complexity of the problem still often defeats a close quantitative analysis, we can understand the nature of the forces which bind atoms together into chemical compounds and these again into larger-scale structures. One great army of physicists is being lured on to explore the mysteries of the fundamental particles, working in the fields of nuclear physics and cosmic rays, and building machines for their experiments whose size is in inverse ratio to that of the bodies they are examining. But there is another great field of physics which has equal attractions. Starting with our ideas about the structure of the atom, we can go back to classical physics, to what used to be generalized as the 'properties of matter,' and interpret them anew in the light of our new knowledge. This is the field to which I have always been attracted. I consider it important that when they come to choose their researches our young students of physics should realize that there are problems here as difficult and as fascinating as those of nuclear physics. Their importance to industry is as great as their scientific interest. This is an age of new materials, and we must attempt to understand how the properties of matter in bulk are determined by its atomic construction.

Our country has played a leading part in the development of X-ray analysis from the first. But we now have so many centers of X-ray analysis in this country that it has been no easy task to choose a team to play for the side. Most of our experts came originally from three schools of research, my father's group at the Royal Institution, the Crystallograph Laboratory at Cambridge, where Bernal inspired many fruitful new lines of work, and my school Manchester. But I cannot forbear contemplating wi considerable pride and complacency all the acti centers where work of first-rate importance is no being done, and I have taken as the subject of m address a review of these centers. It would perha be logical to arrange my matter under subject hea ings—minerals, organic compounds, metal structure etc.—but I do not propose to adopt this plan. I s the development of X-ray analysis as due to a numb of centers, inspired by original and brilliant leade and I wish to consider some of these centers in tur and describe their work.

It is natural to speak of Bernal's work first, becaus no one has done more than he has as an explore and pioneer. Time and again, when reviewing som branch of X-ray analysis which is now very activ we have to acknowledge that the first critical experi ment was due to his inspiration. Settlers have move in to farm the land, but he has been the pioneer wh pushed the frontier forward. In the early days w painstakingly examined X-ray diffracted beams spo by one with an ionization chamber. Highly accura analyses are now made by the far more rapid metho of recording all the beams on a photographic plat The method itself was not new, but it was Berna who showed us how to systematize and docket th observations and draw logical and far-reaching con clusions from them about the architecture of compl compounds. The paper by Bernal and Fowler o water will always be a classic, as showing how muc information could be got from the diffuse X-ray halo produced by a liquid. I well remember his first re view of metal structures and the wide generalizatio he made. It was he who first obtained a regular dif fracted pattern from a protein crystal, and he ad vanced further to study the scattering by the ver large-scale regularities in virus preparations. Thes fields have now been far more intensively studied his work only gave an indication in each case of wha might be discovered, but it made the first steps pos sible.

Another center in London will be represented a this meeting by Mrs. Lonsdale, who started her in vestigation of diffuse X-ray scattering at the Roya Institution. The analysis of crystal structure is base on diffraction of X-rays by the regular pattern o the crystal. Each periodic variation in density du to the repeat of the pattern reflects a corresponding X-ray beam. However, any periodic variation of den sity produces the same effect, and consequently the thermal waves in a hot crystal diffract X-rays, as was first shown by Guinier and Preston. It is in-

d interesting that X-ray analysis should find such unexpected application as a harmonic analyzer the elastic ripples running in all directions in a body. Mrs. Lonsdale was one of the first two men ever to be elected to Fellowship of the Royal ciety. She was shortly followed by another X-ray ystallographer, Mrs. Hodgkin, and we may claim th pride that X-ray crystallography has indeed conuted to history by providing a field in which they ablished their reputations.

Mrs. Hodgkin is to tell us this morning about her rk on penicillin, and no better example could be nd of the art of crystal analysis. I would like remind you of some characteristics of this art. e experimental work consists in recording, indexing, d measuring a large number of spectra or diffracted ams of X-rays, each of which corresponds to a riodic element in the crystal pattern. The number these measurements often rises into four figures. ese periodicities must be accounted for by the rangement of the atoms, and the more complex the ystal, the larger is the number of coordinates which e needed to define the positions of the atoms. The ogress of crystal analysis can be measured by the crease in the number of coordinates or parameters ich can be dealt with. In the first structures my ther and I analyzed in the early days, the atoms re at points of symmetry, and there were no rameters to determine. An early triumph was the alysis of crystals with one parameter, such as calcite d pyrites. But nowadays crystals with anything to 100 parameters are confidently tackled—a task ich would have seemed almost beyond the bounds possibility to the early workers. The inherent fficulty of such work consists in its being very rely possible to deduce the structure directly from e observations. On a strictly analytical basis, the served diffractions might be caused by an infinity structures, since the relative phases of the periicities do not affect the strengths of the diffracted ams, and the solution only becomes unique when e impose certain conditions, in general that the ttern-unit consist of a discrete number of atoms known form. No way has as yet been found of riving directly at a solution consistent with these nditions by a mathematical treatment, though atmpts to do so have been made, and crystallographers ve to fall back on a process of trial and error. In ect, one has to guess a likely structure, calculate w it would diffract, and compare with observation; there is no correspondence, a fresh guess has to be de. So, in solving a crystal with 100 parameters, e is trying to guess successfully all their values multaneously.

The observations themselves are generally not difficult to make. Sometimes a crystal is very small, or unstable; sometimes it is difficult to get a perfect specimen. But on the whole the making of the observations is a matter of routine. The real work lies in their analysis. So, in an X-ray laboratory one finds a deserted room full of apparatus in which the photographs are taking themselves, and a series of annexes in which absorbed workers are wrestling with masses of observations and calculations. I always find it an interesting contrast. Here, on the one hand, are a few photographs of some unknown structure. Hidden in the pattern of diffracted spots lies all the information required to establish the structure, if only one can find the 'open sesame' which would reveal the treasure. The material is so simple, the analysis so very difficult.

How is it done? The analyst has before him the separate bits of a jig-saw puzzle, each one of them being a periodic element in the structure, and he has to fit them together so that they build up a picture which makes sense, meaning by this a distribution of scattering matter corresponding to the atoms which he knows to be there. In making guesses at possible arrangements, he draws on a wealth of experience of the way atoms associate together in space, obtained from previous analyses. He pushes the atoms this way and that, remembering, as he does so, the many other alleys he has previously explored which have proved to be blind. It is, alas, a long time since I last analyzed a structure personally, but I can well remember the intense concentration. One lived with the structure. Finally, after 6 months or longer, and if one were fortunate, everything suddenly clicked into place. An arrangement was found which fitted so well to the most important observations that it was clear that one was on the right track at last. Once the general scheme is discovered, the final adjustments are relatively easy, and one more example is added to the growing list of known structures. Again there is a curious characteristic of this crystal work: we can be sure of our results. Further refinement may be made later, but the evidence that our guess is right in the main is quite overwhelming and certain.

These analyses take a long time and can be made only by the expert. What is the reward which lures him on to concentrate so intensely on establishing a picture of some 20 or 30 atoms arranged in a pattern? There are so many structures to do, and so few people who can work them out, that it seems an endless task to examine them all. But it is not really so hopeless, because the successful analysis of one structure often leads to a quite new understanding of a whole range of forms of matter. The structure of diopside, for example, marked the turning point in our understanding of the nature of all silicates; the structure of

one polyacid shows how they are all built up; the structure of a few simple salts led Pauling to formulate the rules which determine the structure of inorganic compounds in general. It is all the more important that really key structures should be chosen for examination, as likely ventures in which it is justifiable to sink one's capital.

I have made this digression here because the nature of X-ray analysis is so well exemplified by Mrs. Hodgkin's work. Her success in analyzing penicillin is a natural sequel to earlier triumphs, such as the solution of cholesteryl iodide, which verified the nature of a typical sterol complex. She is a leading expert in the most difficult kind of pure crystal analysis, establishing the shape of very complex and unsymmetrical molecules. It is fair to claim, I think, that our country has almost a monopoly of this art in its highest form, and I would like to refer to a few other cases which to me are outstanding examples. One of these is Jeffrey's analysis of geranylamine hydrochloride. Some may wonder why a structure with so exotic a name was considered of high importance, but the point is that it has elements of isoprene linked together, and rubber is polymerized isoprene. This intense study of two joined links of a rubber chain may cast a flood of light on the general nature of rubber-like bodies. Another recent example is the solution of a sucrose compound by Beevers and Cochran. The sugars form very unsymmetrical molecules; in this case a 6-fold and a 5-fold ring are joined together and the bond lengths and bond angles have been determined. I always find an elegance in the method of attack on such complexes which is aesthetically satisfying. The solution seems so obviously right once it has been found, and explains so much.

Beevers is in charge of the Dewar Crystallographic Laboratory in Edinburgh, another center where highly complex molecules are being analyzed like the sucrose molecule mentioned above. His earlier work was largely on water of crystallization and the structure of complex hydrates generally. At present J. H. Robertson, in his laboratory, is making an attack on the alkaloids. The structure of strychnine is still not known with complete certainty, although it has been studied so intensively by the organic chemists. The workers in the Dewar Laboratory have made considerable progress with compounds of strychnine and brucine; it will be a very real triumph if their exact configurations are determined by X-ray analysis.

In another side to the work on organic compounds the emphasis is upon the accurate determination of atomic positions. Robertson at Glasgow has been making a systematic examination of relatively simple molecules in which the chemist already knows the relative positions of all the atoms, his object being to translate such 'chemically known' structures in terms of exact bond lengths and valency angles and correlate them with valency theory. He has determined the carbon-carbon distances in a number of molecules, showing that there are many intermediate stages between the standard single, double, and treble bonds. He is now engaged in a three-dimensional analysis of naphthalene and anthracene, the two structures which were analyzed by my father some 25 years ago and were the first organic compounds ever to be determined. He is examining long saturated CH_2 chains in a series of dicarboxylic acids and finding an alternation of long and short bonds. He is also examining long sulfur chains in polysulfides and polythionates.

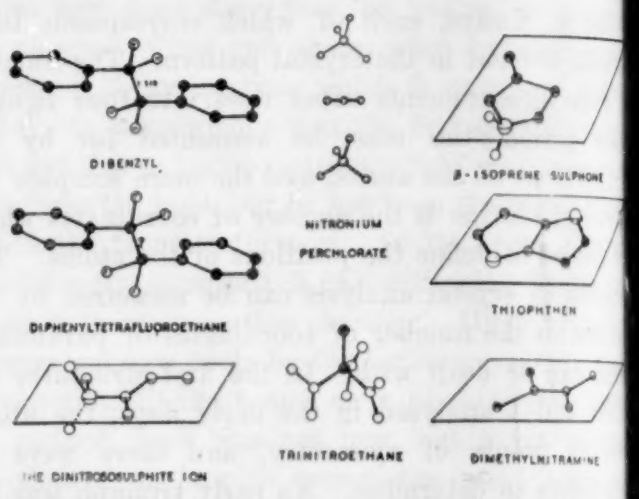


FIG. 1. Examples of structure determinations done in the Chemistry Department, University of Leeds (Prof. E. G. Cox). The shaded atoms are carbon.

Another center where both new structures and bond lengths of known structures are being examined is Cox's laboratory in the Chemistry Department of Leeds. Prof. Cox has kindly supplied me with a composite diagram (Fig. 1) which enables one to see the scope of his recent work at a glance. In diphenyl and the related compound, where hydrogens are replaced by fluorine, the interest lies in the nature of the central bond. It is shorter than the 1.54 A characteristic of a carbon-carbon single bond in diphenyl, and Cox is studying the effect of the fluorine atoms in an attempt to discover the nature of the bond. Nitronium perchlorate is a compound in which $(NO_2)^+$ plays the part of a positive ion, as had been deduced by Ingold on chemical evidence. The analysis of $K_2SO_3 \cdot 2NO$ establishes the nature of the negative ion; chemists have speculated about the structure of this compound for the last hundred years. According to the classical stereochemistry of nitrogen, the N–N bond in dimethyl tetramine should be of the normal single type; it proves to be 1.26 A in length instead of 1.40 A, which is characteristic of a single bond, and to be co-planar with other bonds to the nitrogen atom

it has more of a double-bond character. The other ures show interesting heterocyclic compounds.

Powell at Oxford has an X-ray center which col-borates closely with the chemists. One interesting ne of work has been on complex intermolecular com-ounds—for instance, that of iodoaniline with trinitro-enzene. A similar line of work has been developed James' laboratory at Capetown University. In owell's compounds the two large molecules are of ch a shape that they conveniently pack together in ual proportions. James has studied more complex ses, in which each type of molecule is stacked in ds, and the rods are packed side by side. The re-at distance may not be the same for each kind of d, so that there is no simple ratio between the mber of molecules of each kind, and very complex d beautiful X-ray diffraction effects are produced. rhaps the most striking of Powell's recent analyses s been that of substances which he calls 'clathrates.' inol molecules link together to form two systems interpenetrating networks. Each is like a wire-tting structure in three dimensions, continuous in ace but not bonded to the other though interwoven ith it. There are large open spaces in the meshes, d gas molecules act as 'filters' to occupy these aces and stiffen the two networks relatively to each her. It has long been a mystery how such mole-les as SO_2 could be bound by quinol so firmly that e whole structure had to be destroyed before they uld be released. They are now seen to be very osely held chemically, but completely caged in ysically.

We have at Cambridge a group working on organic emical problems, of which Cochran is the leader. rimidines and purines are being analyzed, as pri-ary building stones in the nucleic acids. This group orks closely with Prof. Todd and his chemists.

The investigations described in the last two para-aphs are essentially part of an enquiry into the ysical basis of the chemical molecule, an attempt understand its dynamics more completely by dis-vering the relative positions of its atoms. The ex-mples given, to which many more could be added, me under the head of 'chemical crystallography.'

The forms of matter which come under the heading 'minerals' are an interesting group. The essential roperty of a mineral is stability; in other words, its oms are arranged in such proportions and positions at a minimum of potential energy is attained lower an that of any alternative grouping. Hence arise th the limited numbers of minerals and the very gid geometrical laws which their structures obey. e deducing of the structural relationships in the ineral kingdom, particularly those in the silicates, s been one of the triumphs of X-ray analysis. The broad outlines of the scheme are now clear, but there are several fascinating lines of work to pursue.

The work which is being carried out at the British Museum of Natural History by F. A. Bannister is an excellent example of the use of X-ray methods. Mineralogists have collected and named varieties from all parts of the globe. There is so much isomorphous replacement in minerals that composition is often an uncertain guide to the identity of a specimen. It is very interesting to note, now that we know more about internal structure, how right the mineralogists have been in allowing themselves to be guided by external form rather than composition in classifying their mineral species and families. But many minerals are in a microcrystalline state where external form is of no assistance. Bannister is carrying out a planned program of mineral examination which is leading to improved identification and classification. New minerals are being discovered which were previously unsuspected constituents of specimens, and minerals to which different names had been assigned are being shown to be of similar structure. Since X-rays readily tell us the number of atoms in each unit of pattern, formulae can be rewritten with far more certainty.

The felspars are the most important constituents of the earth's crust, and are outstanding in their importance to petrologists who study the history of rock formations. They vary in composition and symmetry, but their external form shows that they are closely related. W. H. Taylor first established their structure, showing that they are all based on the same characteristic pattern. Typical formulae are KAl_3SiO_8, $NaAl_3SiO_8$, $CaAl_2Si_2O_8$. The aluminium and silicon atoms form with the oxygens a continuous framework of tetrahedra, in the meshes of which the other ions are incorporated. But, although the same structural type is common to them all, they are rich in variety, and there are many fascinating differences of second order in their structures and properties. Minerals of the same composition may have different optical properties and even different symmetry, and these differences are related to the history and mode of formation of the rock in which they appear. Taylor is now trying to study these finer details. Why does a pure potash felspar appear sometimes to be monoclinic in symmetry and sometimes triclinic? What is the cause of the irreversible change in optical properties which some specimens undergo on heating? How do the structures fit together in felspars which are alternate slices of potassium and sodium felspar? Finally, what is the structure of the intermediate forms between $NaAlSi_3O_8$ (albite) and $CaAl_2Si_2O_8$ (amorthite)? This last is a very intriguing problem. The series has always been regarded as a typical case of simple isomorphous substitution, but X-ray diffraction

shows that it is really a very complex phenomenon. Extra diffraction spots show that larger-scale repeats are superimposed on the simple felspar pattern, in a way which depends on the proportions of sodium and calcium. The problem is interesting for its own sake as an example of X-ray optics, but also important because we wish to understand what conditions have produced these variations in the rocks.

Finally, I must refer to the work on clay minerals which G. W. Brindley is doing at Leeds. Clays are composed of minute spangles of mineral, tiny sheets of mica-like structure which are often polar in their nature. One face of the sheet is different from the other—they have 'bread' and 'butter' sides—and it is probably this polar nature which prevents their crystallizing on a large scale owing to their tendency to curl and warp. These sheets form, as it were, the experimental benches on which the chemical operations in the soil are carried out. Nothing could be more important to soil chemistry than knowledge of the structures of the clay minerals and their related species.

Passing now to the structure of metals, we may conveniently distinguish between two fields of investigation. On the one hand, there is what may be called 'metal chemistry,' the physical basis for the types of structure formed by metal atoms in various proportions; on the other hand, there is the study of what may be called the 'physical geography' of metallic aggregates. By this last is meant the size and orientation of the crystallites in a metal, their strains and structural distortions incipient segregations into different phases such as take place in age-hardening, and exchanges of atomic position such as take place in the order-disorder change. The physical properties of a metal or alloy are much influenced by these characters. On both sides, X-ray analysis has made contributions of really vital importance.

I think it may be fairly claimed that alloy chemistry had no rational basis until structures were determined by X-rays. There is an interesting difference in character between a metallic compound and other kinds of chemical compound. One can, of course, find examples of all intermediate stages, but we are concerned here with broad generalizations. A typical metal compound is composed of markedly electropositive atoms. It follows, as a consequence of the dynamics of such a structure, that wide variations in composition of any one alloy 'phase' are possible. In an extreme case, such as copper and gold, all proportions can unite to form a single structure. This is in complete antithesis to the relationship between sodium and chlorine, for example, when we find pure sodium, pure chlorine, or sodium chloride with the exact stoichiometrical relationship represented by the formula NaCl. To call the former a case of solid solution and the latter a true chemical compound takes us no further in explaining the physical basis of the difference. We may perhaps express the nature of an alloy by saying that different possible arrangements of the metal atoms, or different phases, are separated by fine second-order differences in their potential energy so that very little tips the structure in one direction or another. A compound such as NaCl is at the bottom of a deep, narrow pit of potential energy, and the slightest variation in composition increases the energy greatly. An alloy is at the lowest point of a very shallow bowl with many alternative bowls open to it whose bottoms are nearly at the same level. What is equally important is that metal atoms are very mobile and readily exchange positions, and as a consequence these finer differences have an opportunity to be effective. Hence arises the rich variety of changes that can take place in an alloy system, and the great influence upon it of its thermal or other history.

It would take too long to tell the whole story. I will just remind you of the early work of Westgren on alloy phases, the realization by Hume-Rothery and by Westgren that similar free-electron atom ratios often produced similar phases, the work of Bradley on the structures of complex intermetallic compounds which provided so many examples of the Hume-Rothery rule in binary, ternary, and quaternary phase systems, and the theoretical work of Jones on the explanation of the Hume-Rothery rule by the filling of Brillouin zones.

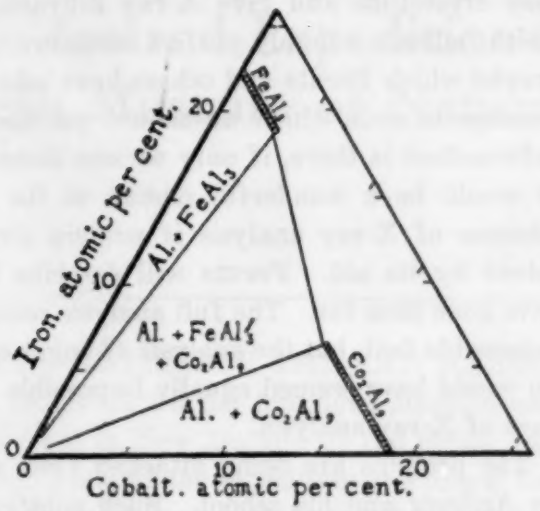
Raynor at Birmingham has as his general objective an understanding of equilibrium relationships and the occurrence and structure of intermediate phases in alloys, so that a comprehensive theory of alloys may be developed, permitting quantitative prediction of the results of mixing metals together. He is concentrating mainly on compounds of aluminium with the transition metals. Fig. 2 will serve as an indication of the type of prediction which may be made.

All this work is still on a semiempirical basis. It is clear that the Hume-Rothery rule corresponds to one highly important factor which determines which phase a given composition of metal atoms will adopt, but also that it is not the only factor. For instance, relative sizes of the atoms play their part as well as the electron-atom ratio. We need to know the structures of far more intermetallic compounds, and these are often very complex and the analysis is lengthy. Mrs. Douglas at Cambridge is collaborating with Raynor, doing the structure analyses of the phase systems he is surveying. If we are examining an inorganic or organic compound, we can safely assume that neighboring atoms have certain well-established relative configurations and conform to rules with which we are familiar. So far we have no such rules for in-

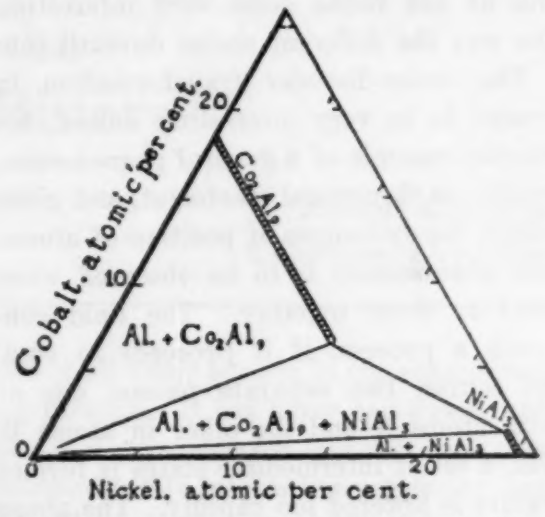
ermetallic compounds, and each structure presents quite a novel problem. We are only at the beginning of an understanding of metal chemistry.

Investigations of alloy phases are concerned with the arrangement of the atoms in the unit cells of a regular crystalline pattern. But the perfect regularity is an ideal state which is attained only under special conditions, and I pass on to describe the application of X-ray analysis to study the many interesting and important types of departure from the ideal lattice.

sociate together. The former state of affairs leads to the well-known order-disorder change, first examined by Borelius and then by Bradley and Sykes, using X-ray analysis. A very imposing literature now exists devoted to this phenomenon alone. Order-disorder is observed only when the composition is near a simple one such as AB or A_3B; the alloy Cu_3Au is typical and has been intensively studied. At high temperatures copper and gold atoms replace each other at random on a face-centered cubic lattice; at lower tem-

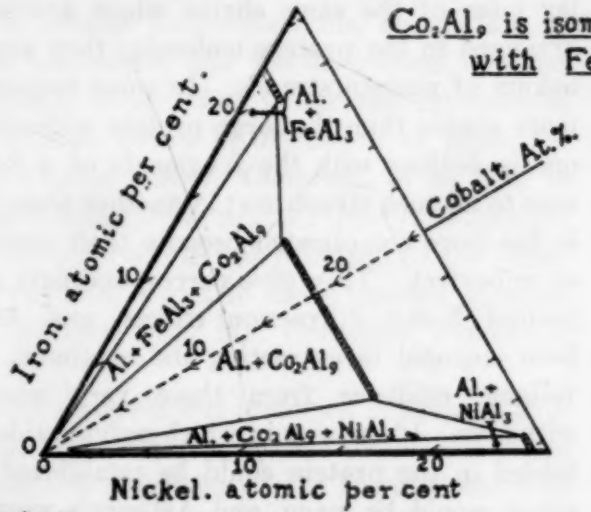


(A) The ternary system: Al-Fe-Co.

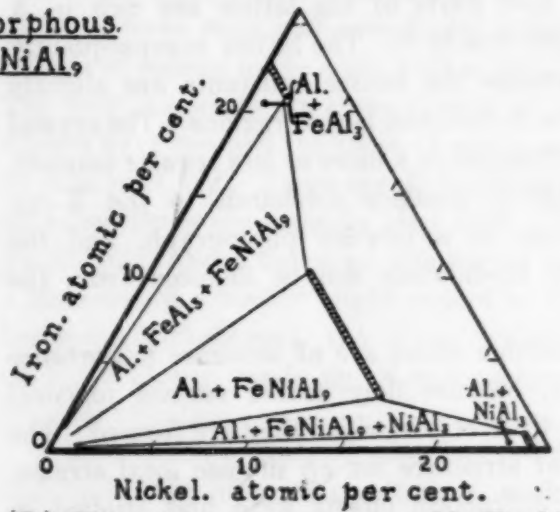


(B) The ternary system: Al-Co-Ni.

Co$_2$Al$_9$ is isomorphous with FeNiAl$_9$



(C) Composite diagram: A + B.



(D) The ternary system: Al-Fe-Ni, showing general correspondence with C.

FIG. 2. Diagrams showing equilibrium at 600° C. A and B represent, respectively, the aluminium-rich isothermals at 600° C for the systems aluminium-iron-cobalt and aluminium-cobalt-nickel. In C, these two diagrams have been redrawn in triangles with angles of 90°, 60°, and 30° and placed together with the aluminium-cobalt axis common. The composite diagram is closely similar to that established experimentally for the aluminium-iron-nickel alloys (D); agreement is quantitative, except that Co_2Al_9 is less sensitive to a reduction in the electron-atom ratio than the less stabile isomorphous $FeNiAl_9$ phase. These relationships are due to the fact that, electronically, Fe + Ni = 2Co. (Dr. G. V. Raynor.)

We know of many cases where two metals are completely miscible over a wide range of composition at higher temperatures, with atoms of either kind occupying the sites of the same lattice in a random manner, but where interesting changes in structure take place when the temperature is lowered. Two broad classes may be distinguished; there may be a tendency for like atoms to get as far apart as possible, or to as-

peratures the gold atoms segregate to the cube corners, leaving the face-centers to the copper atoms. In this way the gold atoms find positions as far apart as the composition permits, and a larger-scale regularity is superimposed on the simpler lattice. The thermodynamics of the change is of such interest as to have attracted theoretical physicists of the order of Bethe and Peierls, among many others. With

different rates of cooling, a series of intermediate states is produced. The ordered states grow from nuclei which are out of step with each other, different points of the lattice being chosen as cube corners for the gold atoms. The more rapid the cooling, the smaller are the domains in which the same scheme of order is preserved. Lipson at Manchester has been investigating these stages more deeply by obtaining diffraction effects from single crystals of Cu_3Au (Sykes had previously used the powder method to establish their existence), and he has found some very interesting features of the way the different nuclei dovetail into each other. The order-disorder transformation in metals has proved to be very interesting indeed, because it is a simple example of a general phenomenon, lends itself readily to theoretical treatment, and gives information about the exchanges of position of atoms.

The converse phenomenon is to be observed when like atoms tend to come together. The final consequence of such a process, if it proceeds to equilibrium, is, of course, two separate phases, one of which is rich in atoms A and the other in atoms B. Again, however, a set of intermediate states is formed if the temperature is lowered too rapidly. The atoms remain in a single continuous crystal lattice, but they segregate so that parts of the lattice are rich in A and other parts rich in B. The lattice is consequently modulated because the lattice constants are slightly different in the A-rich and B-rich regions. The crystal planes are corrugated in a more or less regular manner. Such modulations produce sidebands to the X-ray diffraction lines in a powder photograph, and the nature of the modulation can be deduced from the sidebands.

These metastable states are of immense importance to technology, because they confer certain physical properties on the metal in which they are formed. The modulations of structure set up intense local strains. Their X-ray diffraction effects were first studied in permanent magnet alloys by Bradley. Age-hardening alloys, studied by Guinier and Preston, afford another example. The intensely hard martensitic structure in steel is caused by the dissolved carbon atoms taking up preferred sites, so modifying an initially cubic crystal by making it a mosaic of slightly tetragonal regions which have their C axes in different directions, but still all form part of a single modulated lattice.

The literature which describes the X-ray study of the effect of plastic distortion upon metals would form the material for a book. Preferred orientation, crystal break-down, and the locked-up stresses in the crystallites have been studied. Some very interesting work on this last subject has been done recently by Greenough at Cambridge and at Farnborough, by Lipson, and by Brindley.

These examples only indicate the kind of work which is going on, but they will serve to show the importance of X-ray analysis in metallurgy.

The last field I shall consider is represented by the paper which Perutz is giving to us in this session. X-ray analysis is being extended to more and more complex substances. Can we establish the structure of the molecules of which living matter is made? Protein molecules contain thousands of atoms. Each kind of protein appears to consist of identical molecules, for they crystallize and give X-ray diffraction patterns which indicate a highly perfect structure. The photographs which Perutz and others have taken are like a message in code which we cannot yet decipher. The information is there, if only we can discover the key. It would be a wonderful climax to the progressive advance of X-ray analysis if protein structure were solved by its aid. Perutz will describe how far we have gone thus far. The full analysis seems an almost impossible feat, but the analysis of sugar or of penicillin would have seemed equally impossible in the early days of X-ray analysis.

The proteins are being attacked from another side by Astbury and his school. Such substances as hair and wool, horn nail or spine, are a more or less irregular mass of the same chains which are so perfectly arranged in the protein molecule; they are a kind of oakum of protein strands. In some respects they are more simple than the large protein molecules, because one is dealing with the fragments of a feature common to all such structures; in another sense their study is far more complicated because their arrangement is so imperfect. They give correspondingly diffuse and limited X-ray diffraction effects, and Astbury has been engaged in extracting the maximum amount of reliable evidence from these very unsatisfactory witnesses. If the way in which polypeptide chains are folded in the protein could be established, a big advance would be made, and Astbury's work has done much to help with this problem.

I should have liked to have added an account of the applications of X-ray analysis in some of our great industrial laboratories. Bunn, of I.C.I., has made contributions to fundamental research as well as to the elucidation of technical chemical processes; for instance, he collaborated with Mrs. Hodgkin in the analysis of penicillin. The late A. H. Jay, working in the research laboratory of United Steels, made a name for himself as an expert on refractories. The General Electric Company, Jessops, Firth-Brown, and many other firms have flourishing X-ray centers. The industrial laboratories are as well represented as are the university centers at the annual meetings of the X-ray Analysis Group of the Institute of Physics. But it would lead me too far afield if I were to begin

o do justice to the importance of the contributions rom so many centers, and I have had perforce to con- ent myself with a survey of the work going on in our niversity laboratories.

Laue discovered X-ray diffraction only a generation go. X-ray analysis has now come to be of such importance that the formation of an International Union of Crystallography has been approved by the Council of International Unions this year. It has indeed attained its majority, and I feel deeply moved when, on such an occasion as this, I review the tree which has grown from the seed of Laue's original discovery and the early attempts by my father and myself in 1912 to discover the arrangement of atoms in crystals.

A New Zealand Expedition of the American Museum of Natural History

Robert Cushman Murphy
Chairman, Department of Birds

BETWEEN NOVEMBER 1947 AND MARCH 1948, field work for the American Museum was carried out in New Zealand by the writer and Mrs. Murphy. Aims of the expedition comprised the acquisition of material for two habitat exhibits in the Whitney Memorial Hall of Pacific Bird Life, systematic study of oceanic bird collections, negotiation of intermuseum exchanges, and the excavation of moas and other extinct birds. The writer also represented the Pacific Science Board in discussion of plans for the Seventh Pacific Science Congress, to be held in Auckland and Christchurch next February. Financial support of the undertaking was provided by the Whitney Memorial Fund, a gift to the American Museum of Natural History from Mr. Cornelius Vanderbilt Whitney.

The scientific program was arranged in advance with Dr. Robert A. Falla, director of the Dominion Museum at Wellington and president of the Royal Society of New Zealand. The State Department at Washington simultaneously requested necessary privileges from the New Zealand Government, with the result that the Department of Internal Affairs, acting through Secretary J. W. Heenan, extended generous and effective cooperation during travel and investigation from end to end of the Dominion. Related aid was given by the Marine Department, by the authorities of the museums and university colleges at Auckland, Wellington, Christchurch, and Dunedin, and by other institutions and individuals too numerous to list.

Field operations began at the Snares Islands, 62 geographic miles south of Stewart Island. This small and relatively inaccessible group had not previously been visited for more than a few hours by any scientific investigator. It has the great advantage over nearly all other islands in the subantarctic belt of being pristine. It has never had human inhabitants, introduced organisms are lacking or unobtrusive, and the extraordinarily interesting vegetation and animal life, including daisy-trees (*Olearia*) and the endemic crested penguin pictured on the cover of this issue of *Science,* have remained essentially undisturbed since the era of sealing in the early part of the 19th Century. The only mammals are three species of seals, for the Snares have escaped the curse of man's satellites, such as rats, pigs, etc. There are 25 kinds of native birds, of which three are endemic land birds. The vascular plants total about the same number as the birds. In a zone where a visitor might expect to find antarctic beeches (*Nothofagus*), the dense "goblin forest" is, on the contrary, made up of tree-composites of subtropical affinities.

A band of New Zealand scientists, led by Dr. Falla and including other naturalists, a geologist, and a geodesist, conveyed the American Museum representatives to the Snares in the 73-foot Diesel craft *Alert,* commanded by Capt. Alexander J. Black, of Dunedin, who is himself a well-informed naturalist and a famous leader and instructor of Sea Scouts. A telephonic radio station was established, after which the party of 9 men and 1 woman camped on the main island from November 24 until December 6, 1947, when the vessel returned. Collecting the abundant bird life was limited to specimens intended for installation in the exhibit in New York. Other organisms, such as plant specimens, were more liberally sampled, and, despite characteristically unfavorable weather of the west wind zone, a Kodachrome motion-picture record was obtained of birds, seals, landscape, and some of the activities of the investigators. The

most notable ornithological discovery was that the petrel called the Cape pigeon (*Daption capensis*) nests at the Snares, in the surprisingly low latitude of 48° S. All previously located breeding grounds of this sea bird lie south of the Antarctic Convergence, in the Polar belt.[1]

A significant result of the Snares reconnaissance is that the New Zealand Government has decided to maintain these islands as an inviolate wildlife sanctuary, secure even from the commonly approved annual harvesting of young shearwaters ("mutton-birds") as a food resource.

The second undertaking for the American Museum was carried out at Lake Brunner, Westland, South Island, in January and February 1948. Here studies were made at the edge of virgin mixed podocarp "bush" for the reconstruction of a New Zealand scene of 5 centuries or more ago, when at least one form of moa, and all the more recently extirpated native birds, still flourished. The Government granted permission to collect representatives of the part of the typical New Zealand avifauna that is still common. Newcomers to the Dominion, whether European species introduced by man or relatively recent natural invaders from Australia or Oceania, such as the harrier and the silver-eye, were excluded from consideration, since the exhibit is to represent strictly ancient New Zealand. Rarer birds, such as the kiwi and laughing owl, will be mounted from older study skins in the American Museum, whereas the extinct rail-like takahe (*Notornis*) and a small moa (*Euryapteryx*), the only member of its order known to have been hunted by the Maori aborigines, will be reproduced in facsimile.

Excavations for gigantic birds that disappeared before the arrival of white men were made possible by the liberality of the Canterbury Museum Trust and were undertaken between December and February at the Pyramid Valley Swamp, near Waikari, North Canterbury. This unequaled deposit has been once reported upon before the war,[2] at the beginning of which investigations were temporarily suspended. The site is the now-filled bed of a former forest lake in a pocket between limestone ridges. The matrix in which the bones of hundreds—perhaps thousands—of birds are remarkably well preserved is a curious yellowish, elastic, anaerobic, organic jelly which emits an odor of hydrogen sulfide. An 80-inch cross section of this substance, with its contained fossil or subfossil invertebrate remains, has been submitted for analysis to Prof. Edward S. Deevey, Jr., of the Osborn Zoological Laboratory, Yale University.

Several experienced leaders in New Zealand fossil hunting, including Dr. Falla, Dr. W. R. G. Oliver, Profs. E. Percival, Robin S. Allan, Lance W. McCaskill, and Mr. Edgar F. Stead, took part in and guided the digging, with the result that the skeletons of 2 moas and bones of numerous smaller birds were recovered. The American Museum became the fortunate recipient of individual skeletons representing the following genera of moas, which run the whole gamut of size-range within the group: *Euryapteryx, Pachyornis, Emeus,* and *Dinornis.* The Museum was likewise granted an example of a rare contemporary of the moas, namely, the giant flightless rail (*Aptornis*) of which the first-known practically intact skeleton were recovered during the search here described.

No moa skin or feathers were found in the wet deposits of the swamp, but remains of this nature were studied in the Otago Museum at Dunedin. On the other hand, the Pyramid Valley pits yielded moa stomach contents, with gastroliths and readily identifiable leaves and twigs.

Secretary Heenan, of Internal Affairs, seemed hospitably determined that the visitors from New York should miss no opportunity to inspect the varied physiography and peculiar plant and animal life of New Zealand and to observe the tremendous man-made changes, for better or worse, that have come about in only slightly more than a century. Transportation by train, plane, motor car, launch, trawler, and the Government yacht *Matai* was provided for journeys to most parts of all three main islands. The Alps and other ranges, the lakes, the peerless sounds, fur-seal stations, glaciers, thermal districts, grasslands, the kauri, taxad, and beech forests, the Maori centers, and the bays and outlying islets were seen and enjoyed to an extent rarely possible even for New Zealanders. The islets visited included such classic localities as Little Barrier, Karewa, and Solander.

Most of the strange animals that symbolize New Zealand, such as the kiwi, weka, tuatara, *Amphibola* and *Galaxias,* were observed and also in most cases captured alive, handled, and photographed. Dr. Falla, a foremost authority on the natural history of the southern circumpolar oceans and the best of guides and co-workers, devoted four months of his time almost exclusively to the interests of the Museum. It is anticipated that publication of reports on various aspects of the expedition will continue.

[1] Accounts of the visit have already been published by C. A. Fleming (*N. Z. Bird Notes,* 1948, **2**, 181–184) and Grace E. Barstow Murphy (*Nat. Hist.,* 1948, **57**, 412–416).

[2] This report was made by R. S. Allan, E. Percival, R. S. Duff, R. A. Falla (*Rec. Canterbury Mus.,* 1941, **4**, 325–353).

irst International Congress of Physiology and Pathology f Animal Reproduction and of Artificial Insemination

Banner Bill Morgan

Department of Veterinary Science, University of Wisconsin

HE FIRST INTERNATIONAL CONGRESS of Physiology and Pathology of Animal Reproduction, which was held in Milan, Italy, m June 23 to 30, was considered an immense suc- ss. Representation was world-wide, with a total tendance of over 600 and with delegates from 6 con- ents and 40 different countries. Much of the credit r the success of the Congress belongs to the Secre- y-General and his committee.

The "Lazzaro Spallanzani" Italian Experimental stitute for Artificial Insemination, in cooperation th the University of Milan, promoted the Congress, hich was also held under the auspices of the Italian igh Commission of Public Health and Hygiene, De- rtment of Agriculture, Department of Public In- ruction, War Department, Institute of Foreign Cul- ral Relations, and National Breeders' Association.

At a pre-Congress symposium sponsored by NESCO and FAO, held June 21–22 at the Zoological stitute of the University of Milan, speakers selected direct invitation discussed the problems of "inter- ting substances of eggs and sperm and partheno- nesis."

The Congress dealt with a basic subject, mainly the oblems of animal reproduction. A central piazza th rooms radiating from its central hub provided cellent and valuable opportunity for the scientists make individual contacts with members between ssions and presentation of papers. The stage was roperly set for the stimulation and promotion of change of research discussion on problems of mutual terest. Interpreters were provided, and all talks re presented in the three official languages (English, rench, and Italian). This arrangement also allowed r free discussion.

No country was excluded from participation in the ientific sessions. Although there were no repre- ntatives from Japan and Russia, 11 delegates were esent from Germany, 3 from Austria, 3 from Czecho- vakia, 2 from Bulgaria, 1 each from Spain, Poland, ungary, and Yugoslavia. The largest contingent of gistrants was from Italy (255 members), followed France with 27 members, Great Britain with 26, elgium with 16, the United States with 15, and Den- ark and Switzerland with 12 each.

The Congress was formally opened at the Auditorium of the International Industrial Exhibition of Milan (Fiera Compionaria Internazionale). A series of lectures were presented by: J. Hammond (England), "Endocrine Balance in Relation to Fertility and Sterility"; R. W. Phillips (U.S.A.), "The Relation of Environment Factors to Reproduction in Livestock"; J. Anderson (Kenya), "Climate and Reproduction in Cattle"; G. Amantea (Italy), "Problems and Techniques of Artificial Insemination"; N. Lagerlof (Sweden), "Factors of Sterility"; M. G. Lesbouyries (France), "Avitaminosis A and Infertility"; E. Sorenson (Denmark), "Scientific and Technical Questions of Artificial Insemination"; and J. C. Guitierrez (Uruguay), "Artificial Insemination Problems."

The remainder of the program was devoted to sectional meetings for the presentation of papers. Although some of the papers were scheduled for 60 minutes, the majority were not more than 15 minutes each. The 5 sections on different subjects were scheduled in such a way as to prevent conflicts. The sections were as follows: Section I (61 papers), Biological Problems of Animal Reproduction; Section II (50 papers), Breeding Problems of Animal Reproduction; Section III (54 papers), Pathological Problems of Animal Reproduction; Section IV (45 papers), Methodological and Practical Questions of Artificial Insemination of Animals; and Section V (14 papers), Legislative and Organizational Problems of Artificial Insemination. Dairy cattle research was, of course, given the most emphasis, closely followed by studies on reproduction of sheep and horses.

In addition to the presentation of papers an International Livestock Show and Fair as well as two afternoons of demonstrations were included in the program. Many exhibits were open at all times.

The Italians were excellent hosts to the visiting scientists. Throughout the Congress we were entertained by the authorities of the City of Milan, the Italian Chamber of Commerce, the National Association of Italian Veterinarians, the Università degli Studi di Milano and Società Italiana per Il Progresso della Zootecnica. Luncheons, excursions, and artistic performances were provided.

One of the main attractions of the Congress, pro-

vided by the local committee, was the series of excursions. Since the institute of Spallanzani was one of the first to pioneer in the field of artificial insemination, visits to many of the artificial insemination centers were well worth while.

In the Province of Como visits were made to the Chemical-Pharmaceutical Abattoir in Casatenuova, to Lake Como, and to the Villa Monastero and the Italian Institute for Hydrobiology. A rare opportunity was made possible to visit the birthplace of Lazzaro Spallanzani at Scandiano, as well as the Artificial Breeding Center of the Instituto Beggiani, cooperative milk plants, and the vineyards of Cavalli, all in the Province of Reggio Emilia. Other visits included the famous cathedral and abbey of Certosa di Pavia and the wine cellars of Santa Maria la Versa in the Province of Pavia; the Lake of Garda and the Experimental Zooprophylactic Institute of Lombardy in the Province of Brescia; and agricultural and breeding farms of the Province of Cremona.

The local committee, with Prof. Telesforo Bonadonna as Secretary-General, did a wonderful job of organizing the Congress. All of the meetings were held in the International Industrial Exhibition of Milan, which contains an excellent auditorium a lecture rooms. In the same building informati banking, postoffice, writing, and telephone facili were provided, and light refreshments were availab

The entire program ran with clock-like preci One could go with ease from one session to anot Good projection equipment was provided for lant slides, opaques, and movies. Printed copies of t program with abstracts of all the papers were av able. An itinerary of all the excursions was print For the ladies accompanying members of the Congr an excellent program was arranged.

At the closing session a permanent committee o persons, each from a different country, was elec to manage the affairs of the Congress. T. Bonadon was elected secretary of the permanent committee, a the writer was chosen as a member of the perman committee to represent the United States. This co mittee will meet with the International Veteri Congress in London in August 1949 to plan the n Congress and the establishment of an internatio Institute of Fertility. The Second Congress will held in 1951. It is hoped that more scientists fr the United States will attend the future Congres

NEWS and Notes

William L. Slate, director emeritus of the Connecticut Agricultural Experiment Station, recently accepted the post of consultant at the Agricultural Experiment Station, University of Puerto Rico, Rio Piedras. At the invitation of Arturo Roque, director of the Puerto Rico Station, Mr. Slate will spend the next year acting in an advisory capacity to the Station staff.

Frederick R. Duke, formerly associate professor of chemistry at Michigan State College, is now associate professor of chemistry and associate chemist in the Institute of Atomic Research, Iowa State College.

Gordon F. Ferris, professor of biology at Stanford University and an authority on scale insects, recently flew to China, where he will spend a year in research. Traveling under a research scholarship granted from Fulbright Bill funds, Dr. Ferris will make his headquarters at Lingnan University, located on an island near Canton. He hopes to spend much time in field research and, at the end of his sabbatical year in the Orient, will return to Stanford.

Arthur K. Saz, formerly an instructor at the New York Medical College, was recently appointed professor of bacteriology at Iowa State College.

Leland J. Haworth has been named director of the Brookhaven National Laboratory. Dr. Haworth, who had served as acting director of the Laboratory since the resignation of Philip H. Morse, originally joined the executive staff as assistant director in charge of special projects. In this capacity Dr. Haworth had supervised erection of the nuclear reactor pile and the cosmotron, the two major research tools at Brookhaven.

C. M. Yonge, Regius professor of zoology at the University of Glasgow, has been appointed visiting professor of zoology at the University of California for the first half of the year 1949. Prof. Yonge will be engaged in teaching and research in invertebrate zoology on the Berkeley campus.

Randall McGavock Robertson h been appointed acting director of t Physical Sciences Division, Office Naval Research. Dr. Robertson, specialist in electronics and solid st physics, is filling a vacancy crea when Samuel R. Piore, the direct was granted a leave of absence conduct research at the Massachuse Institute of Technology.

Leverett A. Adams, who fo years was curator of the Museum Natural History at the University Illinois, recently retired. Two ye ago Dr. Adams retired as professor zoology at Illinois. **Donald F. Ho meister** has replaced him as curator the Museum.

Frederick C. Leonard, professor astronomy at the University of C fornia, Los Angeles, was in reside from August 7 to September 9 at t Institute of Meteoritics, Univers of New Mexico, of which he is research associate. From August to 26 he was a member of the In tute's expedition that was mainly sponsible for recovery of the one- Furnas County, Nebraska, achondri This specimen, which fell on Febru 18 of this year, is the largest aeroli

ony meteorite) on record and the gest meteorite of any type ever ob-ved to fall.

Harold P. Knauss has been ap-nted professor of physics and head the department at the University Connecticut. Dr. Knauss formerly ved as director of the Research and velopment Division of the Mound boratory, operated by the Monsanto emical Company for the AEC.

Willard H. Bennett has been desig-ed head of the Physical Electronics tion of the Atomic and Molecular ysics Division, National Bureau of ndards. Dr. Bennett is responsible the recently developed radio-fre-ency mass spectrometer tube and isted in the early development of a -filled cold-cathode rectifier. In new position he will be actively gaged in basic research on cathode ission processes and the physical operties of negative atomic ions.

Leonora Mirone, formerly a re-arch chemist at the Hoffmann Lab-atories, Paterson, New Jersey, has ently been appointed associate ofessor of nutrition research at the iversity of Georgia.

Frederick F. Ferguson recently igned as assistant professor of logy at the University of Washing-to return to active duty as senior istant sanitarian in the U. S. Public alth Service. Dr. Ferguson has n assigned to Savannah, Georgia, ere he will work with the Technical velopment Division of the Communi-ble Disease Center.

John W. E. Glattfeld, associate pro-sor, and **Hermann I. Schlesinger,** ofessor, in the Department of Chem-ry, University of Chicago, recently ired with emeritus status. Dr. hlesinger will continue to work at University on hydrides of light ments, a research project for the val Research Laboratory and Office Naval Research.

Charles C. Shepard, surgeon with National Institute of Health, is sently engaged in a special train-course in chemical biophysics at psala University, Uppsala, Sweden, der Arne Tiselius. The National stitute of Health is planning to send her research officers to laboratories in the United States and abroad for further study and collaborative research.

Raymond H. Ewell recently joined the Stanford Research Institute staff as chairman of the Department of Chemistry and Chemical Engineering. Dr. Ewell formerly served as senior technologist in the Economic Research and Development Departments of the Shell Chemical Corporation, San Francisco, California.

Grants and Awards

The University of Texas College of Pharmacy has received a $5,250 research grant from the Lederle Laboratories, Inc. C. O. Wilson, professor of pharmaceutical chemistry, will direct the project, details of which will be announced later.

Research in chemical tests for intoxication is being undertaken by the Department of Police Administration, Michigan State College, under a recent grant of $5,000 from the National Safety Council. The grant was administered through the Committee on Tests for Intoxication of the Council. C. W. Muehlberger, chairman of the Technical Subcommittee, and Ralph F. Turner, assistant professor of police administration, will direct the project, in cooperation with the Department of Chemistry. Research will incorporate the following: (1) a comparison of chemical techniques for determining alcohol in blood, urine, breath, saliva; (2) intercomparison of results of chemical tests of blood, urine, breath, and saliva to determine the constancy factors of intercorrelation; (3) an evaluation of the factors which go to produce tolerance in the human subject.

The General Electric Education Fund has announced that applications for research grants for 1949–50 are now being accepted. Under this Fund, grants up to $1,500 annually are awarded to college graduates who wish to continue individual study and research in scientific and industrial fields. The Fund, honoring two former G-E presidents, includes the Charles A. Coffin Foundation for fellowships in electricity, physics, and physical chemistry, and the Gerard Swope Foundation, under which fellowships are awarded in the fields of industrial management, engineering, the physical sciences, and any other scientific or industrial field.

Individual fellowships up to $1,500 annually may be awarded, with a grant of $500 available for specific apparatus or other expense in connection with the research. In addition, loans up to $1,000 may also be made. The fellowships are intended for graduates needing financial assistance who have shown by the character of their work that they could advantageously undertake or continue research in this country or abroad. The fellowships are not intended for graduates who now hold, or expect to hold, any other fellowship which carries a stipend larger than the tuition of the institution where the research work is to be done. Further information about the fellowship applications, which must be filed by January 1, 1949, may be obtained by writing to the Secretary, General Electric Company Education Fund, Schenectady 5, New York.

The American Forestry Association's conservation award was presented to Senator Arthur Capper of Kansas on October 9, during the Association's 67th annual meeting in Chattanooga. In announcing the award, S. L. Frost, executive director, pointed out that Senator Capper's many years of work for sound conservation policies and practices included the early development of farm-youth activities, which were the forerunner of the 4-H Clubs now so popular among farm youth throughout the country.

The 1949 John Fritz Medal for scientific achievement has been awarded to Charles Metcalf Allen, professor of hydraulic engineering at Worcester Polytechnic Institute and director of the Alden Hydraulic Laboratory, Worcester, Massachusetts. Prof. Allen was cited "for exceptional achievement in hydraulic engineering" and as "the founder of a notable hydraulic laboratory, prominent teacher, consultant, inventor, and author." This medal, which was established in 1902, is awarded by a board composed of four representatives from each of the four national engineering founder societies, the ASCE, the AIMME, the ASME, and the AIEE.

The American Academy of Arts and Sciences recently awarded its Rumford Premium for outstanding scientific contributions in the field of heat and light to E. Newton Harvey, biology professor at Princeton University and vice-president of the Marine Biological Laboratory at Woods Hole, Massachusetts. Dr. Harvey was honored for his lifelong investigations of the nature of bioluminescence—the power of living organisms to develop heatless light.

The Rumford Premium, according to Harlow Shapley, director of the Harvard College Observatory and chairman of the Academy's Rumford Fund Committee, was established by $5,000 and a letter from Count Rumford in 1796, from London, to John Adams, then president of the American Academy of Arts and Sciences. This sum has now grown to nearly $100,000.

Paul R. Cannon, chairman of the Department of Pathology, University of Chicago, was awarded the Ward Burdick Gold Medal of the American Society of Clinical Pathologists at the recent meeting of the Society. Dr. Cannon, who was honored for his outstanding contributions to the field of pathology, has also been selected to receive the Gold Medal award of the Philadelphia Pathological Society.

Colleges and Universities

The E. J. Longyear Company Fellowship in Metalliferous Economic Geology has been renewed for the current academic year in the Department of Geology, University of Minnesota. The Fellowship has been awarded to Kwang-Chi Tu, who is conducting experiments on hydrothermal alteration at high temperatures and high pressures, under the supervision of J. W. Gruner.

The first of a series of lectures on "Development of the Sciences" was given on October 12 at Yale University by Henry Margenau, professor of natural philosophy and physics, on "What Is Motion?" In the 8 lectures (3 on the physical sciences and 5 on the biological sciences) to be given during the current college year under the auspices of the *Yale Scientific Magazine*, an undergraduate publication, faculty members will attempt to provide liberal arts students with an insight into the development of the scientific method from an historical point of view. The remaining lectures, one of which will be given each month through May, will be by Werner Bergmann, professor of chemistry; Ernest C. Pollard, associate professor of physics; Talbot H. Waterman, assistant professor of zoology; John S. Nicholas, Sterling professor of biology; John F. Fulton, Sterling professor of physiology; Joseph S. Fruton, associate professor of physiological chemistry; and Edmund W. Sinnott, director of the Sheffield Scientific School.

Industrial Laboratories

Edwin J. Fellows, associate professor of pharmacology at Temple University School of Medicine, has recently been appointed head of the newly formed Pharmacology Section within the Research Division of the Smith, Kline & French Laboratories, Philadelphia. During the coming year Dr. Fellows will, however, continue to give lectures at Temple.

Westinghouse Electric Corporation recently organized an Atomic Power Division which will concentrate solely on the harnessing of nuclear energy for the production of useful power. According to Gwilym A. Price, president, the new Division "will be available to undertake atomic energy projects for the U. S. Government as well as to carry on independent studies. It will conduct research, development, engineering, and any necessary associated construction." Charles H. Weaver, a former district industrial manager of the Company, will serve as manager.

Meetings and Elections

The American Philosophical Society's autumn general meeting is being held at the old Custom House, 420 Chestnut Street, Philadelphia, on November 4–5. The Thursday morning session, over which Edwin G. Conklin will preside, will include papers by Frederick Seitz, Carnegie Institute of Technology; Marston Morse, Institute for Advanced Study; W. F. Albright, Johns Hopkins University; and F. H. Roberts, Jr., Smithsonian Institution. Papers in this session will be devoted to the fields of physics, mathematics, and archaeology. St. George L. Sioussat will be chairman of the afternoon session, which will deal with subjects in the fields of history and literature. Papers will be presented by Merle Curti, University of Wisconsin; Bernadotte E. Schmitt, University of Chicago; Marius Barbeau, National Museum of Canada; W. N. Fenton, Smithsonian Institution; and Kemp Malone, Johns Hopkins University. H. L. Mencken will be the speaker on Thursday evening. His topic will be "How Presidents Are Chosen." On Friday morning Ross G. Harrison will preside. Papers in the social sciences will be given by Stith Thompson, Indiana University; Owen Lattimore, Johns Hopkins University; Robert Cushman Murphy, American Museum of Natural History; Mortimer Taube, Library of Congress; and Samuel W. Boggs, Department of State. An executive session will be held on Friday afternoon at 2:00 o'clock.

A Symposium on the Pathogenesis and Pathology of Viral Infections will be held Tuesday evening and Wednesday afternoon and evening, December 14 and 15, at the New York Academy of Medicine, 2 East 103 Street, New York City, under the auspices of the Academy's Section of Microbiology. The meetings will be open to all who are interested in the field. John G. Kidd will be chairman and the speakers will include Richard E. Shope, G. J. Buddingh, Gilbert Dalldorf, Thomas F. Anderson, C. H. van Rooyen, Ralph W. G. Wyckoff, T. F. McNair Scott, John M. Peacock, J. E. Ash, Thomas P. Magill, John G. Kidd, R. D. Lillie, Abner Wolf, and Howard A. Howe.

The National Council of Teachers of Mathematics will hold its Christmas Conference at Ohio State University, Columbus, on Wednesday and Thursday, December 29 and 30. To meet the needs of teachers whose interests vary from the elementary grade to the college level, 6 sections

meetings will be held in addition to the general sessions. Headquarters for the National Council will be in Baker Hall on the University campus. Reservations for rooms and meals should be mailed to Mr. Oscar Schaaf, Room 120, Arps Hall, Ohio State University, Columbus, Ohio, not later than December 15.

The American Society of Mechanical Engineers will hold its 69th annual meeting in New York, November 28–December 3, with headquarters at the Hotel Pennsylvania. More than 6,000 engineers are expected at the 72 comprehensive technical sessions which will cover gas turbines, supersonic flight and rocketry, recent developments in rubber, plastics, and textiles, safety boiler codes and pressure vessels, new metals techniques, and the science of prosthesis. A number of foreign experts will participate in the management and applied mechanics sessions of the meeing. Keynote of this meeting will be "Opportunity for and Responsibility to the Young Graduate Engineer."

An affiliate organization, the American Rocket Society, will hold its annual dinner Thursday, December 2, with Hugh L. Dryden, director of aeronautical research for the National Advisory Committee for Aeronautics, as speaker. The rocket group will confer for the first time three awards set up during the past year, to be given annually for outstanding contributions to rocket development.

The 25th annual Plant Science Seminar was held August 2–5 in Washington State, the program theme being plant physiology and its application to pharmacognosy and related plant sciences. Lectures, demonstrations, and cooperative laboratory exercises at the University of Washington College of Pharmacy were followed by botanizing trips and round-table discussions at Mount Rainier Park. Representatives of the teaching staffs of colleges of pharmacy, of pharmaceutical manufacturing companies, and of research laboratories were in attendance. Officers elected for the 1948–49 term included: J. Allen Reese, University of Kansas School of Pharmecy, chairman; Heber W. Youngken, Jr., University of Washington College of Pharmacy, 1st vice-chairman; J. Hampton Hoch, Medical College of South Carolina School of Pharmacy, 2nd vice-chairman; Edward P. Claus, University of Pittsburgh School of Pharmacy, secretary.

More than 100 geologists from 20 colleges and schools attended the 40th annual field meeting of the New England Intercollegiate Geologists at the University of Vermont, Burlington, on October 9–10.

Charles G. Doll, head of the Department of Geology, University of Vermont, and host to the assembled geologists, was assisted in conducting the various trips by geologists who are well known for their work in the area. Marland P. Billings, Harvard University, and Al H. Chidester, USGS, conducted an economic geology trip to the Waterbury talc mine and the Roxbury Verde Antique quarries. At the mine the relationships between the talc-bearing rock, the serpentine, and the schistose country rock were studied on the surface and in the mine workings. At the Roxbury locality the genetic relationships of the schists, greenstones, and ultrabasics were observed. Donald H. Chapman, University of New Hampshire, conducted the glacial trip, on which much evidence indicating the presence of former glacial Lake Vermont was presented. Shoreline features of the glacial lake phases were studied. On the Hard Rock trip, conducted by Wallace Cady, USGS, and Charles G. Doll, University of Vermont, the Champlain overthrust and the Lower Cambrian formations were studied, the sequence of the formations being followed across the Hinesburg synclinorium eastward from Burlington toward the Green Mt. front.

Informal gatherings were held in the Department of Geology rooms at the University on Friday and Saturday nights. Following the regular meeting on Saturday night, at which time the 1949 field trip was awarded to Dr. Robert Nichols, Tufts College, refreshments were served. Mrs. Charles Doll and Mrs. Daniel T. O'Connell, CCNY, were hostesses.—LLOYD W. FISHER, *Permanent Secretary, Bates College.*

Deaths

Johan Hjort, 79, Norwegian marine biologist, died October 8 in Oslo, Norway. As Director of Fisheries of Norway from 1900 to 1916, Prof. Hjort made major contributions to the fishing industry. As a result of his painstaking explorations on the high seas, marine biologists are able to foretell with much accuracy the fishing prospects for important ocean areas.

J. H. M. Wedderburn, 66, professor emeritus of mathematics at Princeton University, died early in October at his Princeton, New Jersey, home on October 9. From 1911 through his retirement from Princeton in 1945, Dr. Wedderburn had also acted as an editor for the *Annals of Mathematics.*

Mitchell Carroll, 63, head of the Department of Biology, Franklin and Marshall College, since 1920, died October 13 in New England Deaconess Hospital, Boston.

One of the largest and most spectacular exhibits on atomic energy ever shown in the United States will be presented in the Museum of the Franklin Institute, Philadelphia, from November through January 1949. The exhibit, which will explain atomic energy on a nontechnical level, is sponsored by the Brookhaven National Laboratory, under the auspices of the AEC.

Civilian scientists trained and experienced in several scientific and technological fields will be tendered reserve commissions in the Army if they apply and qualify under provisions outlined in Department of the Army Circular No. 210, dated July 14, 1948.

The scientific fields in which the Army has critical need for additional officers include chemistry and chemical engineering, mathematics and statistics, physics, psychology, entomology, forestry, geology, geophysics, and meteorology. Applications will also be received from civilian technologists trained or experienced in such fields as civil, mechanical, electrical, chemical, industrial, mining, metallurgical, and petroleum and natural gas engineering.

Reserve commissions are also available to qualified scientists in 8 medical

allied sciences: bacteriology, biochemistry, parasitology, serology, entomology, nutrition, toxicology, and industrial hygiene.

The commissions range from those of 2nd Lieutenant up to and including Colonel, depending upon the qualifications and experience the individual possesses in his scientific specialty. Applicants must be at least 21 years of age and not exceed 55 years. All must be citizens of the United States. No previous military experience is required.

Application forms and Circular No. 210 may be obtained from local Reserve Unit Headquarters or Organized Reserve Unit Instructors, or by writing to Army Headquarters at New York, Baltimore, Atlanta, Chicago, San Francisco, or Fort Sam Houston, San Antonio, Texas. Information may also be obtained from the Adjutant General, Department of the Army, Washington 25, D. C.

A "Scientists' Committee on Loyalty Problems," which will provide information and legal advice to individual scientists faced with clearance problems, has been established at 14 Battle Road, Princeton, New Jersey, by the Federation of American Scientists. The Committee does not intend to "defend" scientists being investigated but will seek to obtain full and fair hearings by government agencies and Congressional committees as well as fair treatment in the press. Through study of clearance procedures and criteria for judging loyalty the Committee hopes to contribute toward establishment of a sound national policy. A file on clearance procedures and related matters will be maintained, and information will be made available on issues underlying security and clearance problems.

In order that the activities may be more effective and in accord with the views of American scientists, a panel of sponsors and consultants on major policy questions is being set up. The Committee welcomes information on individual clearance cases and also suggestions and criticisms. A fund-raising campaign is being conducted to obtain contributions from scientists and the general public.

Those serving on the Committee include: W. A. Higinbotham, Brookhaven National Laboratory, chairman; A. S. Wightman, Princeton University, secretary; D. R. Hamilton, Princeton University, treasurer; D. Bohm, R. Britten, and R. R. Bush, all of Princeton University; Albert Einstein, Institute for Advanced Study; L. P. Eisenhart, dean emeritus of the Gradute School, Princeton University; S. A. Goudsmit, chief of the "Alsos" war mission, now at Brookhaven National Laboratory; M. S. Livingston, Massachusetts Institute of Technology; Stuart Mudd, University of Pennsylvania School of Medicine; H. D. Smyth, Princeton University; Lyman Spitzer, Jr., director of the Princeton Observatory; Oswald Veblen, Institute for Advanced Study; and Irving Wolff, RCA Laboratories, Princeton.

A national bureau for the international exchange of books and periodicals between libraries and scientific and educational institutions of the United States and other countries opened at the Library of Congress on September 1. The new organization, called the United States Book Exchange, is a successor to the American Book Center for War Devastated Libraries, Inc. Printed materials of a scientific or literary character will be handled first. Inquiries should be addressed to the U. S. Book Exchange, Library of Congress, Washington, D. C.

Make Plans for—

Symposium on "Yeasts in Feeding," November 8–10, Hotel Pfister, Milwaukee, Wisconsin.

American Public Health Association, 76th annual meeting, November 8–12, Boston, Massachusetts.

National Academy of Sciences, autumn meeting, November 15–17, University of California, Berkeley.

American Oil Chemists' Society, fall meeting, November 15–17, Pennsylvania Hotel, New York City.

6th Annual Pittsburgh Conference on X-Ray and Electron Diffraction, November 19–20, Carnegie Institute of Technology.

American Physical Society, 288th meeting, November 26–27, University of Chicago.

American Mathematical Society, November 26–27, Chicago, Illinois.

Recently Received:

Annual report of the All-India Institute of Hygiene and Public Health, Calcutta, 1944–45. Calcutta: Government of India Press, 1947.

Annual engineering undergraduate award and scholarship program for 1948–49. Copies obtainable from the James F. Lincoln Arc Welding Foundation, Cleveland, Ohio.

Guide to Russian scientific periodical literature. (Vol. 1, No. 5.) Upton, N. Y.: Brookhaven National Laboratory, August 23, 1948.

UNESCO: what it is; what it does; what you can do to help. (Department of State Publ. 3225.) Washington, D. C.: U. S. Government Printing Office, 1948. $2.50 per 100. (Pamphlet.)

Chronicle of the World Health Organization. Published monthly by the WHO Interim Commission, 350 Fifth Avenue, New York 1, New York. Single copies, $.20; yearly subscription, $2.00.

Illinois Institute of Technology: annual report of the president for the year ended August 31, 1948.

The Nutrition Foundation, Inc.: report of scientific director, June 30, 1948.

What's new for the laboratory (No. 6). Bloomfield, N. J.: Scientific Glass Apparatus Co., October 1948. (Pamphlet.)

Annual report of the Chicago Natural History Museum, 1947. Chicago: Museum Press, 1948. $1.00.

Esso Research Center, a description of the work being carried on by the Standard Oil Development Company. Copies obtainable from Standard Oil Company (New Jersey), Room 1626, 30 Rockefeller Plaza, New York 20.

Checklist of Chicago area amphibians and reptiles, by R. A. Edgren, Jr., and W. T. Stille; The northern limit of the range of *Laemanctus serratus*, by James A. Peters; Rapid fat production by ground squirrels preceding hibernation, by Otis Wade; A specimen of the white-tailed jack rabbit, *Lepus townsendii*, from Illinois, by D. F. Hoffmeister and L. G. Grebner. Natural History Miscellanea Nos. 26, 27, 28, 29, published by the Chicago Academy of Sciences, 2001 N. Clark Street, Chicago 14.

TECHNICAL PAPERS

udies of the Molybdenum Nutrition of ants With Radioactive Molybdenum

P. R. Stout and W. R. Meagher

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f the 15 known essential elements for the growth of her plants, molybdenum is the most striking by reason the small amounts needed, healthy plants having as le as 10 parts per billion of their green weight as ybdenum.

n association of molybdenum with plant life was first rulated by Ter Meulen (*11*), based on molybdenum ys of organic materials from a wide variety of sources uding land and aquatic plants and samples of coal petroleum collected from different parts of the ld. A year earlier, H. Bortels (*3*) found that *Azototer chroococcum* required molybdenum where its growth pended upon the fixation of atmospheric nitrogen. inberg (*9*) demonstrated that molybdenum was essen- for the growth of *Aspergillus niger*.

Direct evidence of the necessity of molybdenum for growth of higher plants was much delayed, principally ause of experimental difficulties in refining nutrient dia so that they were sufficiently free from molybdenum produce deficiency symptoms in plants, and because ns of effecting chemical analyses of the small amounts the element were not available.

An early recognition of the existence of unknown microrient elements required for the growth of higher plants made by Hoagland and Snyder (*5*) in work reported h strawberries grown in culture solution. Their work wed specific responses to copper, boron, manganese, zinc, and also to an unknown factor within a group 11 other elements including Rb, Ba, Sr, Cd, Hg, Pb, Cr, Mo, W, and V.

Arising directly from their observations and intensive k on the zinc nutrition of plants associated with the ttle leaf'' or rosette disease of fruit trees, a program undertaken to provide quantities of chemicals, water, appropriate containers which could be used to grow nts under more rigidly controlled cultural conditions.

Based on Steinberg's (*8*) procedures of purifying nuent media, large-scale cultural methods satisfactory for sistently producing micronutrient element deficiencies re developed and used to grow crop plants (*10*). Apcation of such methods established the specific role of ybdenum as an essential element for the growth of her plants, as reported by Arnon and Stout (*2*).

The small amounts of molybdenum required by the nts, although making chemical investigations difficult, re as an illustration of ''small things that make great erences.'' For example, Anderson (*1*), reviewing molybdenum investigations in Australia, reports field trials showing a progressive increase in the yield of legumes from 590 to 2,022 lbs dry weight/acre with increasing applications of MoO_3 from 1/64 to 1 oz/acre. Extensive areas in the Mount Lofty Ranges of South Australia having molybdenum-deficient soils of low fertility can be made productive through fertilization provided molybdenum is also applied in amounts of this order of magnitude.

There is much of interest to the student of plant nutrition in the specific role of molybdenum in the physiology of plants. Evidence of an association of molybdenum with nitrogen metabolism exists throughout the work of investigators dealing with this subject since Bortels' original finding that molybdenum was required for the fixation of atmospheric nitrogen by *Azotobacter*. In fact, the remarkable molybdenum response of certain Australian pastures cropped with legumes is thought to be due to an increased efficiency of nitrogen fixation by symbiotic nitrogen-fixing organisms (*1*).

Molybdenum nutrition of higher plants is also apparently associated with the nitrogen cycle. Specifically, Hewitt and Jones (*4*) and Mulder (*6*) have shown that molybdenum-deficient plants do not efficiently reduce nitrate nitrogen after it has been absorbed and translocated to the upper parts of plants. Their findings have been verified in our laboratories. Molybdenum-deficient plants grown with salts further purified with coprecipitation of molybdenum with CuS have shown the effect of supplying minute amounts of molybdenum strikingly reflected in the reduction of nitrate nitrogen in the leaves of the molybdenum-deficient plants. For example, leaves of molybdenum-deficient tomato plants were found to accumulate nitrate to the extent of 12% of their total dry weight. Additions of molybdenum to deficient plants resulted not only in the formation of chorophyll, as evidenced by the chlorotic plants becoming green, but also in the reduction of nitrate from 12% to about 1% on a dry weight basis. Recovery was rapid, 48 hrs being required to bring about these changes.

Radioactive molybdenum isotopes as a means of effecting chemical measurements in submicrogram amounts. Two radioactive isotopes of molybdenum of high specific activity have been prepared for studies of the molybdenum nutrition of plants. They were produced by alpha bombardment of ZrO_2 in the University of California's 60″ cyclotron and were isolated in ''carrier-free'' amounts by ether extraction as indicated under Table 1. The activity has been assigned to formation of Mo^{93} and Mo^{99} through the reactions $Zr^{90}(\alpha n)Mo^{93}$ and $Zr^{96}(\alpha n)Mo^{99}$.

Identity of the radioactive isotopes with molybdenum was made by adding stable molybdenum salts to the radioactive material extracted by ether and then demonstrating a constant ratio of molybdenum to radioactivity

in products of subsequent chemical separations. Two chemical methods were used. First, it was shown that the partition between ether and hydrochloric acid was quantitatively the same for stable molybdenum and the radioisotope (Table 1A); and second, a series of precipitates of $(NH_4)_3PO_4 \cdot xMoO_3$ made from an acid solution of tagged $(NH_4)_2MoO_4$ likewise showed a constant ratio of molybdenum to the radioactivity of each precipitate (Table 1B). Details of yields and methods of preparation of the radioisotopes will be reported elsewhere.

TABLE 1

CHEMICAL IDENTIFICATION OF RADIOACTIVE MOLYBDENUM SEPARATED FROM ZrO_2 IN CARRIER-FREE AMOUNTS[1]

A. Distribution of Mo* (+ carrier Mo) between 6*N* HCl and ether saturated 6*N* HCl

Ratio = Vol. of HCl / Vol. of ether	Mo extracted by ether[2] (μg)	Activity extracted by ether (cpm)	Ratio = Activity extracted / Mo extracted
2.1	1.17	405	346
3.5	0.88	306	348
6.8	0.55	190	346

B. Precipitation of Mo* (+ carrier Mo) as $(NH_4)_3PO_4 \cdot xMoO_3$

PO_4 added (mg)	Wt. of ppt (mg)	Mo in ppt[2] (mg)	Activity in ppt (cpm)	Ratio = Activity / Mo content
0.2	3.8	2.2	527	240
0.4	7.6	4.3	1020	237
0.6	11.5	6.2	1530	247
1.0	18.0	9.6	2359	246

[1] The ZrO_2 was removed from the target and dissolved in the presence of 5 mg of Cb_2O_5 as a "hold-back" carrier for columbian isotopes. Solution was effected by boiling in 12*N* H_2SO_4 down to fuming. NaCl and HCl were added, following cooling and dilution with water, to bring the (H^+) and (Cl^-) to 6*N*. The Mo was extracted with ether saturated with 6*N* HCl.

[2] Spectrophotometric determination of molybdenum by the thiocyanate-stannous chloride method (7).

Absorption of Mo^{93} and Mo^{99} by plants. Short-time absorption experiments with tagged molybdenum have been made using young tomato plants as experimental material. Tomatoes were grown in complete culture solutions. At the time of the experiment single three-week-old tomato plants ranging between 6″ and 10″ in height were transferred to one-quart jars. Oxygen was supplied during the absorption period by passing air through sintered Pyrex aerators into the culture solution.

Some of the experiments were conducted with Mo^{93} (half-life, 6.7 hrs) being the dominant radioisotope, and other experiments have been made using Mo^{99} (half-life, 67 hrs). In each case, 1 μg of molybdenum was tagged with the radioisotope and added to the culture solution as a molybdate salt for adsorption studies with plants.

Particular points of interest resulting from these experiments. (1) A complete accounting of the absorption and subsequent distribution of a single microgram molybdenum in growing plants has been obtained u an experimental arrangement analogous to that used absorption studies with the micronutrient elements.

TABLE 2

INFLUENCE OF VARIOUS INORGANIC IONS[1] ON THE ABSORPTI OF SUBMICROGRAM AMOUNTS OF MOLYBDENUM[2] FROM CULTURE SOLUTIONS DURING A 24-HR PERIOD[3]

Cation	NH_4^+		K^+		Ca^{++}	
Anion of salt in solution	Blades	Stems	Blades	Stems	Blades	Stem
NO_3^-	140	15	89	21	173	5
Cl^-	110	22	38	7	57	1
$H_2PO_4^-$	200	68	500	110	230	11
$SO_4^=$	21	1	5	3	26	

Figures in the table are cpm/gm fresh weight. One of $\overset{*}{Mo}$ is equivalent to 5,170 cpm.

[1] Salts were used at a concentration of 0.005*N* with spect to the cation.

[2] Mo was added as $\overset{*}{MoO_4^=}$ at a concentration of 1 μg Mo/liter.

[3] Plants were kept in greenhouse; the day was sunny.

(2) Radioautographs obtained show a distinctly ferent type of distribution of molybdenum within plant tissues than for other mineral nutrients, e.g. macronutrient elements, potassium and phosphorus, micronutrient elements such as manganese and zinc.

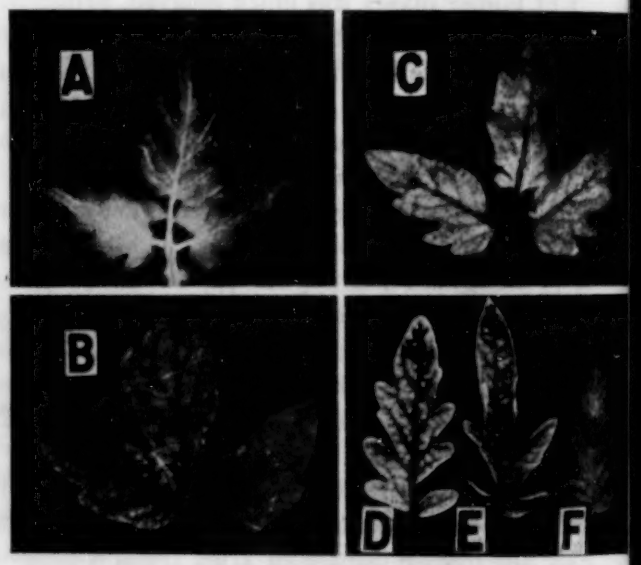

FIG. 1. A, B, C: radioautographs of K^{43}, Mo^{93}, and Mo^{99}, respectively; D, E: photographs of Mo-deficient leaflets; F: photograph of normal leaflet.

(3) Roots accumulate molybdenum rapidly from cult solutions, even though the concentration with respect molybdenum is initially established at 1 part per bill and is reduced below that value as absorption proce

(4) Translocation of these submicrogram amounts molybdenum from roots to upper parts of the plant takes place rapidly, but the amounts translocated strongly influenced by the concentration of phosphate in the culture solution (Table 2). Many other absorp experiments completely verify this phosphate-molybden interrelation.

Points 1 and 2 are made evident by the radiographs in ig. 1. Comparison of the radiograph of potassium in tomato leaf (Fig. 1A) with the radiographs of molybenum (B, C) shows that molybdenum is accumulated in terveinal areas in direct contrast with the potassium attern. It is not accumulated by stem tissue to any reat degree—another point of direct contrast with otassium.

It is evident, from the characteristic patterns of molybenum accumulation, that this element, unlike other minral nutrient elements of which we have knowledge, is ot rapidly accumulated by actively metabolizing plant ells adjacent to the vascular tissue in the upper parts f the plant. Areas within the leaf where the molybenum does accumulate are also the areas having the reatest number of stomatal openings. Accumulation ould therefore result from molybdenum being left at oints of greatest water loss.

In the absence of molybdenum, loss of chlorophyll takes lace in the same interveinal regions. This may be seen y comparing the photographs of molybdenum-deficient eaflets (D, E) showing the chlorotic areas caused by olybdenum deficiency with the molybdenum radiographs B, C). Accumulation of molybdenum in the chlorotic reas after it is supplied to the culture solution suggests n alternate possibility of molybdenum being tightly held n these areas by plant compounds directly involved in etabolic processes which are either peculiar to, or more ctive within, the interveinal areas of the leaf—for exmple, the reduction of nitrates referred to earlier, which ould be considered as one step in the metabolic cycle.

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Molybdenum Deficiency in Serpentine Barren Soils

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The infertility and unique plant distribution patterns of serpentine barren soils recently prompted an investigation of the mineral nutrition of certain native and agricultural species grown on such soils. As a part of this study, tomato plants were grown in pot culture experiments designed to test the effect of variations in the soil calcium level. Marked responses to increased calcium were obtained, similar to those already reported for serpentine soil (*10*), but anomalous symptoms remained. The type of abnormality appeared to be identical with that characterizing molybdenum-deficient plants grown in water cultures in the Division of Plant Nutrition at this University.

The first abnormalities were yellowing and curling of the leaflets of the first or second pair of true leaves. Development of typical molybdenum-deficiency symptoms, as described by Arnon and Stout (*3*) using water cultures and Hewitt and Jones (*7*) in water and sand cultures, followed these initial signs. Pronounced mottling appeared in all true leaves, the veins remaining light green and shading into the chlorotic interveinal areas. Advanced symptoms were puffing of the chlorotic areas and marked upcurling of the leaflet margins. Finally, the tips of the leaflets and areas along the margins began to shrivel and later die. Newly formed leaves were green, but during expansion became mottled and curled.

Molybdenum deficiencies in higher plants grown on soils in Australia, New Zealand, and Central Europe have been reported (*1, 4, 5, 6*), but the writer knows of no previous observation of molybdenum deficiency on soils in the Western Hemisphere. In Australia, legumes grown on certain pasture soils showed marked response to molybdenum in both field and pot tests (*1, 2, 6, 9*), and perennial rye grass responded in pot cultures (*9*). Davies (*5*) observed characteristic molybdenum-deficiency symptoms in cauliflower growing on an acid New Zealand soil and was able to bring about rapid recovery of the plants with molybdate fertilization. Mitchell (*8*), also working in New Zealand, prevented the occurrence of the whiptail disease in cauliflower and broccoli by applications of ammonium molybdate in field plots.

In order to substantiate the symptomatic diagnosis of molybdenum deficiency in the affected tomato plants of this study, chemical analyses were made in the Division of Plant Nutrition to establish their molybdenum content. These showed that the level was less than 0.1 ppm on a dry weight basis (see Table 1), which was lower than any previous assay for molybdenum made in those laboratories on soil-grown plant material.

Molybdenum was then supplied to affected plants in order to check further the indications that they were molybdenum deficient. Direct corroborative evidence was obtained through the recovery of the affected plants after supplying them with molybdenum. Three methods were used: (1) application of small amounts of molybdate salts to the soils, (2) painting of leaflets with a dilute solution of Na_2MoO_4, and (3) direct infiltration of Na_2MoO_4 into cut leaflet tips. Also, a few treatments were made with manganese without success. Specific procedures with results obtained are outlined below.

(1) *Fertilization.* (a) Application of Na_2MoO_4 in solution to the top of the soil at the rate of 0.81 lb of Mo/acre to young mottled plants caused definite greening up in 48 hrs and complete loss of leaf mottling in 4 days. Of 30

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mottled plants in one experiment, 26 were fertilized with molybdenum and 4 held out as untreated checks. *Every one of the fertilized plants lost the yellowish mottled appearance and assumed a normal green color within 4 days,* while the unfertilized plants became more yellowish and mottled.

TABLE 1

MOLYBDENUM ASSAYS OF TOMATO TISSUE

Tissue analyzed	Dry weight (gm)	Mo present (μg)	Mo in dry tissue (ppm)
Older, chlorotic leaflets	4.45	0.50	0.11
Younger, nonchlorotic leaflets	1.20	< 0.07	< 0.06
Stems (including petioles and rachises)	2.76	0.17	0.06
Total of above fractions	8.41	0.74	0.09

(b) Similar fertilizer applications, as $(NH_4)_6Mo_7O_{24}$ at the rate of 1.00 lb of Mo/acre to older plants having severely chlorotic and curled leaves, gave essential recovery in 7 days. Mottling disappeared, and growth was accelerated, although some curling and necrosis persisted in the older, heavily damaged leaves.

(2) *Leaf painting.* Young mottled leaves painted with a water solution of Na_2MoO_4 containing 100 ppm of Mo appeared to be fully recovered after 4 days, and the adjacent leaves greened up as well. Similar painting of other leaves with $MnSO_4$, 100 ppm in manganese, did not remedy the mottled condition.

(3) *Leaf infiltration.* The terminal leaflet of a lower leaf on a severely affected plant was cut transversely and the cut end dipped into a vial containing Na_2MoO_4 solution, 10 ppm with respect to Mo. Greening up was noticeable even in the most chlorotic leaflets after 3 days, and the entire plant was essentially recovered in 5 days. Treatment of another plant in a like manner using 10 ppm of manganese had no beneficial effect.

The same symptoms have been observed in tomato and corrected through molybdenum fertilization on two other serpentine soils, with results similar to those indicated under "fertilization" above. No exceptions to recovery after soil fertilization have been noted in 51 separate treatments of affected tomato plants.

Limited evidence also indicates that Romaine lettuce suffers from molybdenum deficiency on the one soil tested. The symptoms are a pale yellowish color, spindliness, and retarded growth. Plants showing such symptoms in one experiment were fertilized with Na_2MoO_4 at the rate of 1 lb of Mo/acre, which restored the normal green color of the plants in 5 days and markedly improved their vigor.

The three soils involved are shallow, primary hillside soils overlying crystalline serpentine rock in Lake and Marin Counties, California. The areas are sharply delimited serpentine barrens with characteristically sparse endemic floras. These soils are:

(1) A red, gravelly loam from Lake County, classified in the Henecke soil series. Its pH is 6.8 as read on the saturation paste with a glass electrode; the calcium-magnesium ratio in the base exchange complex is 0.17; content of organic matter is low; and X-ray powder diagrams of the 2-μ clay fraction show only characteristic lines of kaolinite.

(2) A brown, gravelly loam of the Montara series from the south slope of Mt. Tamalpais, Marin County. The pH is 6.3; the calcium-magnesium ratio in the base exchange complex is 0.286; and the organic matter content is low.

(3) An unclassified, gray, stony loam from the northwest slope of Mt. Tamalpais, Marin County. The pH is 6.7; the calcium-magnesium ratio in the base exchange complex is 0.148; and the organic matter content is high.

Plants were grown from April through June 1948 and began to show deficiency symptoms about two weeks after transplanting. In similar experiments conducted during the winter months this condition was not so obvious, although, particularly in the case of the lettuce, it is believed that the deficiency existed but was not properly diagnosed. Rapid growth which occurred during the spring season apparently accentuated the deficiency.

No particular precautions were taken to prevent contamination with micronutrient elements in these greenhouse experiments. Marglobe tomato seeds were germinated in sand for most of the experiments and the seedlings transplanted to potted soils when the first true leaf was 1½ to 2 cm long, while lettuce seedlings were grown on loam soil and transplanted when the first true leaf was 3 to 3½ cm in length. A few tomato seedlings were germinated directly on the Henecke soil and then transplanted to the 6″ pots when the first true leaf was 2 cm long. These plants exhibited deficiency symptoms at an earlier stage of growth than those which were germinated on the sand. The 6″ red clay pots were covered with two coats of black asphalt varnish. All pots were uniformly fertilized with C.P. chemicals (154 ppm N, 20[illegible] ppm P_2O_5, and 154 ppm K_2O in the air-dry soil) and irrigated with distilled water, but calcium levels varied from 11% to 80% calcium in the base exchange complex. The same symptoms were present, however, on the unaltered field soils having 13%, 14%, and 22% exchangeable calcium, respectively, for the unclassified gray loam, the Henecke, and the Montara soils.

Presence of molybdenum deficiency in the three primary serpentine soils so far subjected to test, coming as they do from different areas and varying widely in organic matter content, suggests that low available molybdenum may be a general chemical characteristic of primary soils weathered on serpentine parent material. In addition to probable peculiarities in their calcium-magnesium nutrition, plant species native to the serpentine barrens may also have a lower molybdenum requirement than that of the crop plants used in these tests.

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Irradiation of the Hypophysectomized Rat

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In a previous communication we reported that X radiation, in common with other types of stress, appeared to result in an increased demand for the adrenal-cortical hormone (*3*). In general, the pattern of the adrenal response to irradiation in the lethal range consisted of a reduction in adrenal cholesterol initially, a normal or elevated cholesterol concentration associated with adrenal hypertrophy in the intermediate period, and a second marked fall in adrenal cholesterol terminally. Subsequent studies revealed that the initial reduction in adrenal cholesterol observed 3 hrs after X irradiation could be prevented by suitable administration of adrenal-cortical extract (*9*). This substantiates the findings of Sayers and Sayers (*5*), who found that the previous administration of cortical hormone prevented the rather similar fall in adrenal ascorbic acid seen in rats stressed by exposure to cold. The intermediate and terminal adrenal responses to irradiation, however, were not modified by the daily administration of cortical extract in an amount sufficient to prevent the initial cholesterol change, nor was the survival of irradiated rats altered by such treatment (*9*). Even when the dose of extract was increased 5-fold, the usual adrenal changes were observed 4 days after irradiation (*4*).

It is generally agreed that the early depletion in adrenal lipids and ascorbic acid seen after a variety of stressing stimuli, as well as the subsequent adrenal hypertrophy, are mediated through the pituitary adrenotropic hormone (*1, 2, 7, 10*). Since the possibility exists that the adrenal glands may play a role in mediating or modifying some of the changes observed after irradiation, it seemed of interest to determine whether hypophysectomy would prevent the adrenal response to X radiation and to note whether survival and some of the typical changes in organ weights would be altered under these conditions.

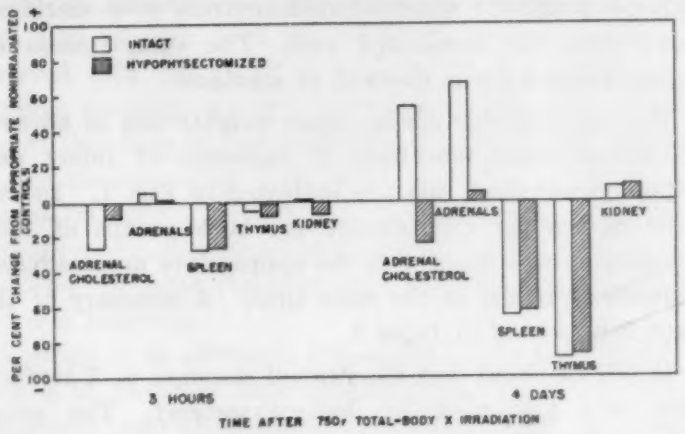

FIG. 1. Per cent change in adrenal cholesterol and organ weights in intact and hypophysectomized rats after 750 r. (Cholesterol and organ weights expressed as per cent of body weight in calculating per cent change. Minimum of 10 rats in each group.)

TABLE 1

ADRENAL CHOLESTEROL AND ORGAN WEIGHTS IN INTACT AND HYPOPHYSECTOMIZED RATS AFTER 750 r

Group	Sacrifice time: After hypophysectomy	Sacrifice time: After X-ray	No. of rats	Body wt. (gm)	Adrenal cholesterol (mg/100 mg of adrenal)	Adrenal cholesterol (mg/100 gm of body wt.)	Adrenal wt. (mg/100 gm of body wt.)	Spleen wt. (mg/100 gm of body wt.)	Thymus wt. (mg/100 gm of body wt.)	Kidney wt. (mg/100 gm of body wt.)
Intact										
Nonirradiated	.....	.....	14	278.5	1.90 ± 0.18*	0.25 ± 0.03	12.8 ± 0.4	301 ± 11	184 ± 6	346 ± 6
Irradiated	.....	3 hrs	10	268.9	1.37 ± 0.12	0.18 ± 0.02	13.5 ± 0.5	221 ± 8	174 ± 10	351 ± 5
"	.....	4 days	10	220.0	1.77 ± 0.24	0.38 ± 0.04	21.4 ± 0.9	104 ± 8	20 ± 1	374 ± 9
Hypophysectomized										
Nonirradiated	7 days	.....	10	194.3	4.11 ± 0.41	0.41 ± 0.05	9.8 ± 0.8	267 ± 10	190 ± 12	310 ± 7
Irradiated	7	3 hrs	10	204.4	3.74 ± 0.19	0.37 ± 0.08	9.9 ± 0.5	198 ± 9	174 ± 9	289 ± 9
Nonirradiated	11	.....	10	188.8	3.18 ± 0.36	0.30 ± 0.03	9.4 ± 0.3	215 ± 8	179 ± 9	290 ± 7
Irradiated	11	4 days	12	168.4	2.39 ± 0.28	0.23 ± 0.03	9.8 ± 0.4	81 ± 4	24 ± 1	317 ± 9
Nonirradiated	14	.....	5	199.9	2.36 ± 0.76	0.20 ± 0.07	8.4 ± 0.6	217 ± 8	168 ± 14	273 ± 7

* Indicates mean and standard error.

Sixty white male rats (Sprague-Dawley) weighing 200–300 gm each received total-body X radiation in a single exposure (750 r; 200 kv; dose rate, 18 r/min). Thirty of the rats were hypophysectomized one week prior to irradiation. The animals were exposed in groups of 10, each exposure group containing equal numbers of intact and hypophysectomized rats. All rats including the normal and hypophysectomized nonirradiated controls were fed bread and milk, Fox Checkers, and water *ad libitum*. Animals were sacrificed with Nembutal (IP) 3 hrs and 4 days after irradiation, and the adrenals, spleen, thymus,

and left kidney were removed, dissected free of fat, and weighed on a torsion balance. Total adrenal cholesterol was determined on paired adrenals from single animals by the Schoenheimer-Sperry method as modified by Sperry (*8*). Appropriate nonirradiated controls were sacrificed along with the irradiated rats. The completeness of hypophysectomy was checked at sacrifice.

The per cent changes in organ weights and in adrenal cholesterol after total-body X radiation of intact and hypophysectomized rats are indicated in Fig. 1. In calculating the per cent change for both groups of rats, comparison was made with the appropriate nonirradiated controls sacrificed at the same time. A summary of the data is presented in Table 1.

It will be noted that the adrenal response to X irradiation was prevented by hypophysectomy. The small changes seen in adrenal cholesterol and adrenal weight at 3 hrs and 4 days were not statistically significant. Furthermore, the terminal adrenal changes which are observed in intact animals were not seen in two hypophysectomized irradiated rats sacrificed in a moribund condition. Statistically significant changes identical with those reported previously were observed in the unoperated irradiated animals.[1]

Pituitary ablation did not alter the degree or time course of the splenic and thymic involution resulting from X irradiation. Kidney, which was weighed as a control, did not change appreciably in either group after irradiation. The small increase noted in kidney weight calculated on the basis of body weight may be accounted for by the observed decrease in body weight.

Hypophysectomy appeared to potentiate X-ray toxicity. Forty-five per cent of 20 hypophysectomized irradiated rats died 3–4 days after the exposure, whereas none of the intact irradiated animals succumbed at this time. Deaths in the latter group began at 6 days, and there was only a 30% mortality by 16 days after the irradiation. There were no deaths in the nonirradiated hypophysectomized group.

Atrophy of the adrenals was evident in the hypophysectomized group at the time of irradiation, 7 days after the operation (22% decrease in adrenal weight calculated on the basis of body weight). At this time the concentration of cholesterol in the gland was increased above that observed in the intact rat. However, the total cholesterol content of the adrenals was almost equivalent in both groups. Adrenal weight was decreased still further and the cholesterol concentration was reduced in the animals sacrificed 11 and 15 days after the operation. Rather similar changes in adrenal cholesterol in hypophysectomized rats have been described by Sayers, *et al.* (*6*), and Tyslowitz has reported a gradual fall in adrenal ascorbic acid after removal of the pituitary (*11*).

[1] It should be pointed out that the concentration of cholesterol in the adrenals of the intact nonirradiated rats was low in comparison with the many determinations made by us previously on other shipments of rats. We cannot account for this. The control rats were sacrificed at different intervals during the course of the experiment, and no gross evidence of disease was found.

There is evidence which suggests that the response of the adrenal cortex to the pituitary tropic hormone is dependent upon a certain level of activity of the cortical cells and diminishes with time after hypophysectomy (6). It remains to be determined, therefore, whether the adrenal cortex in the 7-day hypophysectomized rat does not respond to X radiation because it is generally less sensitive, owing to the removal of pituitary influence, or because its stimulation after irradiation is mediated solely by the adrenotropic hormone. In order to evaluate this point we plan to study the adrenal response in animals irradiated 2–3 days after hypophysectomy, before appreciable glandular atrophy and decreased sensitivity are evident. Nevertheless, we may conclude from the present experiments that hypophysectomy performed one week prior to irradiation prevents the intermediate and terminal as well as the initial adrenal changes resulting from exposure to X-rays. Under these conditions, the extent of the splenic and thymic involution is not altered, although toxicity appears to be enhanced.

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The Inhalation of Norisodrine Sulfate Dust

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There have been many favorable reports on the use of Norisodrine Sulfate as a bronchodilator. This drug has been known in the European literature as Aleudrin and has been chemically identified as 1-(3′,4′-dihydroxyphenyl)-2-isopropylaminoethanol. Its chief clinical use has been in the symptomatic treatment of asthmatic conditions. A considerable number of animal and human experiments have been carried out in relation to the properties of this drug. There is general agreement in the literature that (1) it is more effective than epinephrine in overcoming bronchiospasm induced experimentally; (2) it may cause vasodilation with a consequent fall in blood pressure; (3) it may cause an increase in the

nary output; (4) it may cause tachycardia, dizziness, nausea if given in large doses subcutaneously; (5) e is very little evidence of addiction; (6) it has en effective in asthmatic patients who could not ob- relief with epinephrine, theophylline, or ephedrine; there is no evidence of "fastness" for this drug; (8) inistration by inhalation appears to be the route of ice; (9) it is effective when given orally, sublingually, cutaneously, and by inhalation.

revious reports (*5–7*) have indicated that the inhala- of penicillin in the form of a dust is a very practical efficient means of introducing a drug into the respira- tract. The inhalation of penicillin as a dust, it is

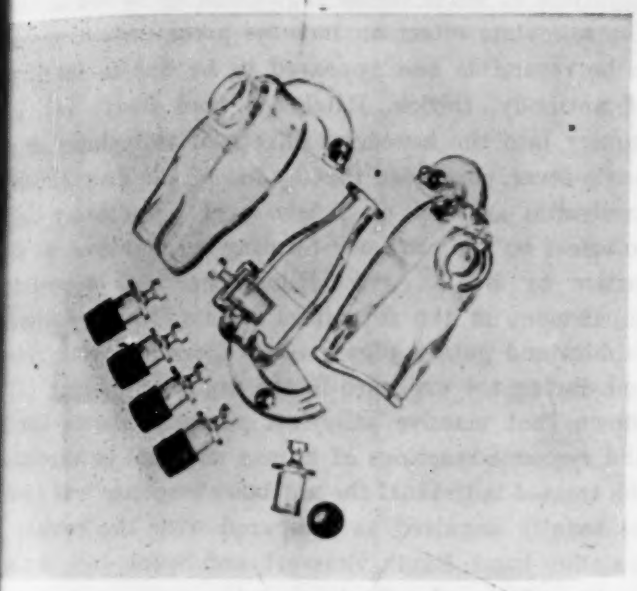

FIG. 1

inted out, has a number of mechanical and therapeutic rantages, including simplicity of equipment and ad- nistration, maximum concentration of drug per unit a within the respiratory tract, slow absorption of the g into the systemic circulation, lack of necessity for ution of the drug, and use of a pocket-size apparatus ich may be kept on one's person for instantaneous use all times; in addition, no oxygen or nebulizer is re- red to aerosolize medicament. It was believed that se advantages could apply to Norisodrine if used in t form and at the same time widen the application of drug with such useful clinical properties.

The apparatus consists of a molded plastic discharge amber with a detachable mouthpiece (Fig. 1). The risodrine dust is contained in a small plastic cartridge, bottom of which is fitted with a fine-mesh wire screen rough which the Norisodrine dust is released. The per rim of the cartridge exhibits two small flanges ich fit into a groove and allow locking the cartridge position in the discharge chamber. The distal end this chamber is formed into a curved tube runway taining an aluminum ball. On inhalation, the alumi- m ball is rapidly drawn up the runway until it strikes cartridge containing the Norisodrine dust; the impact uses the release of a small amount of the dust into the scharge chamber. The upper end of the runway is ooved so that the air to be inspired can bypass the uminum ball after it strikes the cartridge. The in- spired air, as it bypasses the ball, carries the released dust into the respiratory passages. Thus, with each respiration a small but uniform amount of dust enters the respiratory passages until the total dose has been consumed; this is usually accomplished within 3–5 min.

In view of some mild, but definite, untoward reactions observed with the use of Norisodrine Sulfate in aqueous solution, the response of 6 normal subjects to the inhalation of this drug in dust form was studied. Each subject inhaled the amount of dust (3–5 mg) released during one normal inspiration. Pulse rate, blood pressure, and subjective reports were recorded following inhalation. Pulse and blood pressure readings were taken immediately and at 2-min intervals.

A group of 24 asthmatic patients with histories ranging from 3 to 28 years were studied. These patients were apparently not satisfactorily controlled with the usual drugs such as epinephrine, either by injection or by inhalation, aminophylline, iodides, ephedrine, pyribenzamine, or Benadryl. Seven patients were classified as having bronchial asthma with bronchitis, and 17 as having bronchial asthma of the allergic type. All patients were taken off their previous medication and given a test dose of Norisodrine dust[1] to determine the presence of any unusual sensitivity or untoward reactions. The test dose consisted of the amount of drug released by one inspiration. The patients were then instructed to take one whiff of the Norisodrine dust during an impending attack of asthma. This was to be repeated within ½–1 hr as necessary.

It soon became apparent that, on the basis of the clinical response to the inhalation of Norisodrine dust, the patients fell into two basic groups. One group could be completely and satisfactorily controlled by the exclusive use of the Norisodrine dust. The second group could be controlled by Norisodrine only when either aminophylline and iodides and/or an antihistaminic were being used daily. In the latter group it would appear as if the "threshold" of bronchospasm was lowered by the use of this additional medication, thus making Norisodrine more effective in controlling the asthmatic paroxysm. It should be pointed out, however, that these same drugs did not prevent the occurrence of asthmatic attacks but rather made it possible for these paroxysms to yield to the Norisodrine. Response to inhalation of Norisodrine dust was evaluated in terms of how completely impending asthmatic attacks were aborted or the extent to which the actual attack was dissolved. Sixteen patients were controlled by the inhalation of the Norisodrine dust alone. Seven of these had an associated bronchitis and were given penicillin dust inhalation subsequently, although the asthmatic paroxysms were previously controlled with Norisodrine alone. The penicillin dust therapy in this type of case greatly reduced the need for the Norisodrine. Eight patients required aminophylline and iodides and/or an antihistaminic in addition to the Norisodrine. These patients received the

[1] The Norisodrine dust was processed and furnished through the courtesy of the Abbott Laboratories, North Chicago, Illinois.

aminophylline by mouth daily. In one instance the patient could not be controlled with Norisodrine plus additional medication, but she did not respond to epinephrine either.[2] Of the 8 patients requiring medication in addition to Norisodrine, 1 patient did not respond to Norisodrine at all, 4 patients gave a good response, and 3 responded satisfactorily. The results in these patients requiring additional medication might have been anticipated, since they did not respond to Norisodrine alone. In those instances where no additional therapy was required the response to Norisodrine was satisfactory in all instances. In normal subjects the inhalation of a single dose of Norisodrine dust did not appear to influence the pulse rate or the blood pressure. No discomforting symptoms were reported by this group. Four asthmatic patients reported symptoms of dizziness and/or palpitation after the inhalation of the Norisodrine dust. These reactions were not alarming and disappeared in all instances within 10 min. The blood pressure changes in these 4 patients showed a drop in systolic pressure ranging from 3 to 20 mm of mercury. In this group of 4 patients the pulse rate showed an increase ranging from 4 to 12 beats/min. There were no reactions in the remaining 20 patients. One patient, treated while in status asthmaticus, required a considerable amount of Norisodrine to maintain comfort. Since she tolerated the drug exceptionally well, she was permitted to inhale the Norisodrine dust freely. This patient consumed as much as 100 mg of the drug daily without any untoward reactions whatsoever. None of the patients, including the latter, has so far shown any tendency of fastness toward this drug. This group of patients has been using Norisodrine dust for 10 months.

On the basis of the clinical results obtained with the inhalation of Norisodrine dust, either alone or in addition to other medication, it would appear that this drug has a definite place in the symptomatic treatment of asthmatic diseases. It should be useful in many instances of bronchospasms of a nonasthmatic origin. It can apparently be inhaled in dust form with a wide margin of safety.

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[2] This patient appeared to be resistant to all forms of therapy. Her attacks would persist for 3–5 days and then stop spontaneously.

Inhibition of Anaphylactic Shock by Acetylsalicylic Acid

BERRY CAMP

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Data have recently accumulated which indicate effect on antigen-antibody reactions of members of salicylate group. Coburn and Kapp (*2*) reported salicylates modify the precipitation of normal ra serum protein by tungsten and partly inhibit the cipitation of horse serum euglobulin by rabbit antise The salicylate effect on immune precipitation was n to be reversible and appeared to be due to inactivat of antibody. Derick, Hitchcock, and Swift (*3*), in inquiry into the beneficial effects of salicylates on r matic fever, concluded that by use of the drug circula antibodies are kept at a low level, presumably thro an effect on the antibody-forming mechanisms, as sh earlier by Swift (*8*). Homburger (*4*) reported impairment in the formation of anti-Rh agglutinin rabbits and guinea pigs given sodium salicylate prio and during the exposure to the antigen. Jager (*5*) shown that massive salicylate therapy aborts the l and systemic reactions of human subjects to vaccine. the treated individual the antibody response was foun be usually impaired as compared with the control. the other hand, Rantz, Boisvert, and Spink (*6*), in a st on the effects of salicylates, sulfa compounds, and p icillin on antibody response to streptococcal (sore thr infection, found no significant alteration of antib response in those individuals treated, rather cons atively, with sodium salicylate. In a more recent pa Sullivan, Parker, and Hibbert (*7*) report protection rabbits against arteritis, apparently through interfer with antigen-antibody reaction.

The experiments reported below were designed clarify the protection offered by these drugs to aphylactic shock and were related to a study of t effects on neurotropic virus disease.

Young adult (ca. 2-kg) rabbits were sensitized to albumin by injection of egg white on alternate day the following doses: 1 cc, i.v.; 0.5 cc, i.v.; 1 cc, Acetylsalicylic acid was used as the drug and was ministered orally as 5-grain (0.324-gm) tablets. animals were restrained in a stock-like box and the tab inserted, with long forceps, well back in the mouth. squirt of water from a syringe followed the tablet speeded its dissolution. Care was taken to replace drug which was spit out.

Twenty-one rabbits were sensitized on March 24, 1 At 2:00 P.M. on April 9, 11 were given 5 grains acetylsalicylic acid orally. This was repeated at 10 P.M. the same day and at 10:00 A.M. on April 10. hour later, these animals, together with the remaining for controls, were injected intravenously with 0.6 c egg white. Nine of the 11 experimentals (Table showed no shock, the remaining 2 showing moderate

shock, respectively. All of the 10 controls showed , 2 died, 1 was severely shocked, and the rest showed rate or mild shock.

ree weeks later some of the survivors of both the rimental and the control group were again challenged ut the drug with 0.6 cc of egg white, i.v. All showed k.

TABLE 1

ECTS OF ADMINISTRATION OF 15 GRAINS (.968 GM) OF ACETYLSALICYLIC ACID, IN DIVIDED DOSES, ON ANAPHYLACTIC SHOCK

Dosage	Shock	21 days later
15 grains in 3 doses	0	..
"	0	3
"	0	4
"	0	1
"	0	..
"	0	..
"	0	..
"	0	..
"	0	..
"	2	..
"	1	..
None	3	4
"	2	4
"	1	1
"	1	..
"	4	..
"	2	..
"	2	..
"	1	..
"	2	..
"	4	..

o test the effect of acetylsalicylic acid on histamine , 11 rabbits weighing 2–2.5 kg were given 5 grains cetylsalicylic acid, orally, at 3:30 P.M. on March 11, . This dosage was repeated at 9:00 A.M. on March nd again at 2:30 P.M. the same day. One hour later, rabbit was injected intravenously with 2.75 mg of mine phosphate. Seven of the 11 died (#4 shock), owed severe (#3) shock, and 2 showed moderate) shock.

e animals which were premedicated with acetylsal- c acid showed striking protection against anaphy- c shock. It may be presumed, on the basis of the ature reviewed above, that this was due to a de- e in the antibodies at the time of the challenging . There is nothing to indicate any protective effect st histamine shock, for though unaccompanied by ltaneous controls, the morbidity in the above series similar to that reported in a previous communication . It is interesting to note that the effects of the drug temporary and that the treated animals showed iderable hypersensitivity 3 weeks later.

e contrast between the results with this drug and reported earlier (7) for Benadryl is complete. dryl gave good protection, in similar experiments, st histamine shock but was without effect on an- lactic shock. The present drug, acetylsalicylic acid, ever, effectively protects against anaphylactic shock not against histamine. It is, with the other salicyl-

ates, apparently a true antianaphylactic drug in that it interferes with the antigen-antibody reactions to prevent or decrease the untoward results of the challenging dose of antigen.

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Effects of 2,4-Dichlorophenoxyacetic Acid on Chicks[1]

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With the increasing use of 2,4-D as a herbicide it is important to inquire into the possible toxic effects of the chemical on animals. Several investigators have studied the effects of 2,4-D on mammals. The lethal dose for mice, when injected subcutaneously or intravenously, has been determined by Bucher (*1*) to be 280 mg/kg of body weight. Mitchell and Marth (*2*) reported that they fed 200 mg of 2,4-D daily to small experimental animals with no ill effects.

TABLE 1

EFFECT OF ALKANOLAMINE OF 2,4-D ON WHITE ROCK CHICKS

Dosage (mg of acid/kg of body weight)	Increase in weight at end of four weeks (%)
0.00 (control)	456
.28	444
2.80	469
28.00	427
280.00	373

In the present experiment White Rock chicks were used. The alkanolamine of 2,4-D was administered orally through a pipette. In the first experiment, data for which are given in Table 1, one part of the alkanolamine was diluted with 19 parts of water. The dosages recorded are in terms of the acid equivalent. Five chicks (each weighing approximately 50 gm at the beginning) were used in each group. The chicks were weighed and then were given the appropriate dose (Table 1) three times a week on alternate days for a period of four weeks, making a total of 12 doses. As the chicks gained in weight, the

[1] Contribution No. 210 from the Department of Botany and the Rocky Mountain Herbarium, University of Wyoming.

amount administered was adjusted in order to maintain the original dosage. At the end of four weeks they were again weighed. The table shows the percentage increase in weight for the four-week period.

The differences between the control group and those given dosages of 0.28, 2.80, and 28.00 mg/kg were not significant at the 5% level. The difference between the control group and the group given a dosage of 280 mg/kg was barely significant at the 5% level.

Next, experiments were started to determine the lethal dose of the alkanolamine of 2,4-D when diluted 1:9 with water. Each chick of a group of 5 (each averaging 166 gm) was given one dose of 380 mg/kg of body weight. These chicks survived.

Each chick of another group of 5 chicks (average weight, 111 gm) was given a dose of 765 mg/kg of body weight. All of these chicks died. Postmortem examination revealed a fatty degeneration with a pale mottling of the liver, spleen, kidneys, and heart. Hemorrhagic gastroenteritis was also evident.[2] Hence, for small chicks the lethal dose of diluted 2,4-D is somewhere between 380 and 765 mg/kg.

The fact that a single dose of 765 mg killed, but not a total dose of 3,360 mg administered over a four-week period (280 mg/kg chicks of Table 1), indicates that the alkanolamine of 2,4-D is not a cumulative poison.

The question might be raised as to the possibility of chicks being killed by feeding on plants which had been sprayed with 2,4-D. At a spraying rate of 1 lb of 2,4-D/acre, a chicken weighing 1 kg would have to consume *all* of the 2,4-D applied on 72 sq ft within a day or two to obtain a lethal dose.

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A New Histological Procedure for Whole Tissue Cultures Grown in Plasma

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Standard textbook procedures (*2, 3*) recommended for fixing and staining whole tissue cultures in plasma coagula have proven unsatisfactory for the following reasons: (1) The dense fixed coagulum presents a nearly impermeable barrier to the stain, thus necessitating prolonged staining periods; (2) the coagulum itself stains diffusely and heavily, preventing adequate contrast between the cells and the medium and necessitating careful and time-consuming decolorizing and developing procedures; (3) the resulting preparation, when mounted, is thick, has a tendency to form air bubbles, does not dry readily, and is generally inadequate for microscopic study. Tompkins, Cunningham, and Kirk (*4*) recently attempted to improve results by washing cultures in salt solution for 4 hrs at 7° C to remove soluble proteins before fixation, but still had to resort to prolonged staining (1 hr in Delafield's hematoxylin) followed by several hours of washing. Earle (*1*) has devised complicated fixing, staining, and mounting procedures, too elaborate to warrant evaluation here.

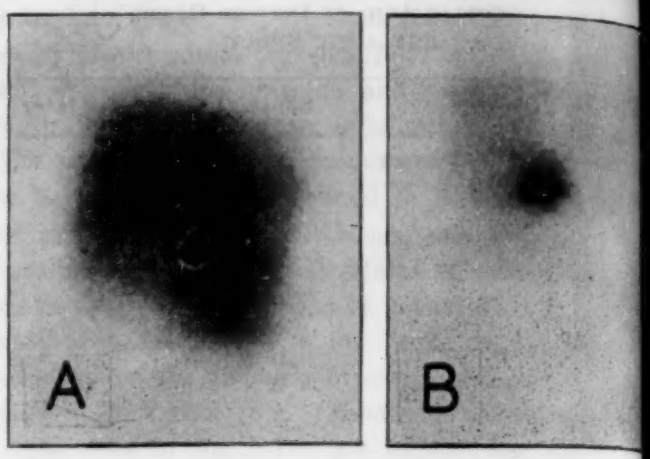

Fig. 1. Gross appearance of stained tissue cultures. A, plasma undried; B, plasma dried (×1.5).

We have found that most of the disadvantages of plasma coagulum can be eliminated by drying the whole tissue culture preparation after fixation. The procedure is as follows: The culture in its coagulum on a cover slip is fixed overnight in 3–4% formol containing 0.5% acetic acid or in Carnoy's fluid for 1 hr. In general, acetic-alcohol fixations give a more granular and more opaque dried specimen than acetic-formol fixations. The cover slip is then washed *thoroughly* in running water (after acetic-formol) or in descending strengths of alcohol, and water (after Carnoy's). After a final rinse in distilled water the cover slips are laid flat on a glass surface, protected from dust (Petri dishes or staining dishes may be used) and allowed to dry slowly and thoroughly in air. If a preparation of a tube or a flask culture of plasma is desired, the portion should be fixed and washed *in situ*, pried loose and placed, like a paraffin section, in a dish of water, where it can be manipulated with a dissecting needle onto a slide or cover slip previously coated with a thin film of Mayer's albumin, and dried as above. Cultures grown in a fluid medium should not be dried. The dried cultures may be stained with any one of the hematoxylins for from 5 to 15 min, depending on the strength of the stain. Weigert's iron-hematoxylin has been found very satisfactory. The staining is simple to control after a preliminary trial, and prolonged washing to develop the color is not necessary. Once stained the cultures should not be allowed to dry again. Following this, the cover slips are passed through the alcohols in the usual manner, cleared in xylene, and mounted. If a Leishman or Giemsa stain is used, acetone and acetone-xylene dehydrations should be employed instead of the alcohols. The dehydration and clearing procedures take considerably less time with dried cultures, since

[2] The authors are grateful to Robert W. Lindenstruth, who made the examinations.

FIG. 2. Microscopic detail of portion of culture prepared by the method described. Rat embryo spleen, fixed in Carnoy's fluid, Leishman stain (×600).

tion does not have to penetrate a wet gel-like gulum.

he mounted preparations are thin and easily visual- under the high-power objectives of the microscope. y dry completely in 24–48 hrs in an incubator and be filed upright. The dense, heavily stained back- ound of the usual total culture mount is either absent considerably diminished. The cells stain evenly and rply and show no more distortion of structure or inkage than cells fixed and prepared by any other thod.

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emoval of the Fertilization Membranes om Large Quantities of Sea-Urchin Eggs

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n the course of developing a method for separating a large scale the meso-, macro-, and micromeres of sea-urchin 16-cell stage we have had, first of all to ise a means of removing the fertilization membranes. is is usually done on a small scale by sucking the eggs ough a fine capillary pipette, with a diameter just ge enough to allow the eggs, but not the membranes, pass. In this way, some hundreds of eggs can be dealt h quite quickly. Multiplying the fine opening of the pette many times by using a sieve of bolting silk, as posed by Just (*1*), we have removed the membranes m large quantities of eggs in a matter of seconds. is method, which may perhaps be of interest to others rking with sea-urchin eggs, is described briefly below.

With a sieve of this kind, three factors are important: (1) the exact moment for treating the eggs, (2) the mesh of the bolting silk, (3) the rate at which the eggs are passed through the silk. Since fully elevated membranes are most easily torn off and since the membranes harden rather soon after elevation, the time interval for treatment is limited. With *Paracentrotus lividus* we have found, as have others, that the best moment for removing the membranes is about 30 sec after the beginning of elevation. For the eggs of this species, with a diameter of about 90 μ at Roscoff, we have found bolting silk No. 13xxx (70×70 μ) to be suitable. If an egg suspension is allowed to flow by its own weight through this mesh of bolting silk, the membranes pass unbroken. If, however, a water suction pump is used to draw the suspension through the silk at a high speed, all the membranes are removed, but many eggs are broken. To draw

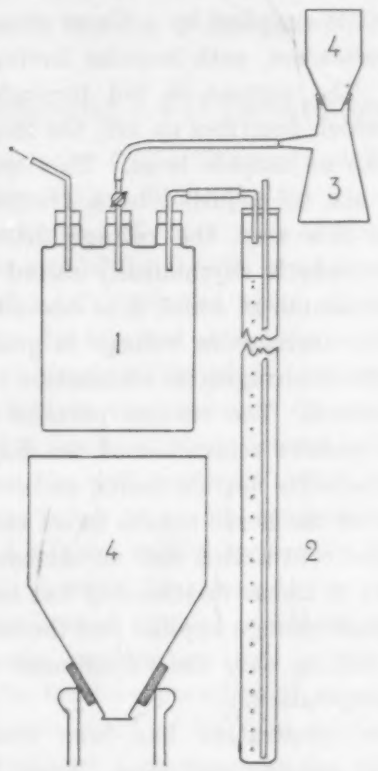

FIG. 1

the eggs through at the right speed we have used the arrangement shown in Fig. 1. A 2,000-cc Wolf flask (1), with three openings, is connected to a water suction-pump, to a water-column pressure regulator (2), and, via a tap, to a small suction flask (100–250 cc) (3). The container for the egg suspension (4), which has an opening at the bottom (diameter, 18 mm), covered with bolting silk, sits in a rubber packing on this suction flask.

Before use, the pressure regulator is filled in order to give a negative pressure of 800–1,000 mm of water (the denser the egg suspension, the greater the pressure needed). The tap is closed and the suction pump is turned on, thus lowering the pressure in the Wolf flask, until the regulator allows air to come in. The eggs are then inseminated, and the suspension is transferred to the container just before the membranes are fully elevated. The tap is opened, and the suspension is sucked into the

flask. In this way, the fertilization membranes of 98–100% of the eggs can be removed.

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Electrophrenic Respiration

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A new type of artificial respiration has been developed which uses electrical stimulation of one or both phrenic nerves. Current is supplied by a Grass stimulator set to deliver 40 impulses/sec, each impulse having a duration of 2 millisec. The current is fed through a rotating potentiometer which describes an arc, the length of which can be set by an adjustable lever. This lever is driven at a rate that can be adjusted by a friction clutch arrangement. In this way, the voltage delivered to the stimulating electrode is rhythmically raised and lowered at that rate per minute at which it is desired to maintain respiration. The increase in voltage is gradual and results in a smooth diaphragmatic contraction that produces effective inspiration. The reverse permits effective expiration by the passive relaxation of the diaphragm.

Within satisfactorily flexible limits, an increase in peak voltage applied to the nerve results in an increased force of diaphragmatic contraction and an increased tidal and minute volume. A linear relationship has been shown to exist between peak voltage applied and the minute volume accomplished, making easy the adjustment of the effective depth of respiration.

Electrophrenic respiration has been studied in the rabbit, cat, dog, monkey, and man. From the obtained data the following observations have been made:

(1) A smooth diaphragmatic contraction, closely resembling that seen during spontaneous respiration, follows the application of a gradually increasing voltage applied to the phrenic nerve.

(2) The ventilation accomplished by stimulating the phrenic nerve is, within satisfactory limits, directly proportional to the peak voltage applied.

(3) The spontaneous minute volume, arterial blood oxygen and carbon dioxide tensions of the experimental animal and man can be duplicated by the use of electrophrenic respiration with the submaximal stimulation of one phrenic nerve in the absence of spontaneous respiratory activity.

(4) Maximal stimulation of one phrenic nerve can produce overventilation and alkalosis. Bilateral maximal phrenic nerve stimulation produces a further decrease in arterial blood carbon dioxide tension and may triple the animal's spontaneous minute volume. These facts indicate the reverse of the method.

(5) An adequate minute volume and normal arter blood oxygen and carbon dioxide tensions have b maintained in the cat for as long as 22 hrs in the a sence of spontaneous respiratory activity by elect phrenic respiration.

(6) The experimental animal under anesthesia a unanesthetized man promptly relinquish control of r piration when adequate electrophrenic respiration sta

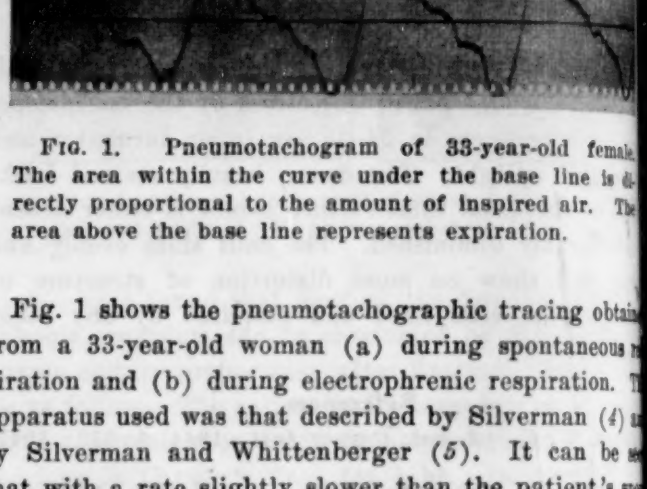

FIG. 1. Pneumotachogram of 33-year-old female. The area within the curve under the base line is di- rectly proportional to the amount of inspired air. The area above the base line represents expiration.

Fig. 1 shows the pneumotachographic tracing obtai from a 33-year-old woman (a) during spontaneous r piration and (b) during electrophrenic respiration. T apparatus used was that described by Silverman (*4*) a by Silverman and Whittenberger (*5*). It can be se that with a rate slightly slower than the patient's spo taneous rate, electrophrenic respiration produced a lar tidal and minute volume than that produced by spon neous respiration.

In the same patient, studies of arterial blood oxyge tion with the Millikan oximeter (*1*) revealed that arteri saturation could be increased over spontaneous levels b means of electrophrenic respiration.

Since the preparation of this manuscript, an opport nity arose for using this method of artificial respirati on a 5-year-old boy with complete respiratory paraly following rupture of a cerebral aneurysm. As the on means of artificial respiration, it was capable of sustai ing life for 52 hrs. Additional data are in press co cerning the blood gas tensions and minute volum achieved with this technique (*2*), its use in man (6 and the mechanism of suppression of spontaneous respir tory activity during electrophrenic respiration (*3*).

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Comments and Communications

ecedence of Modern Plant Names Over mes Based on Fossils

omment regarding my proposal (*Science*, April 2, pp. –345) to use modern material for nomenclatural ification whenever possible, even though a congeneric il group was named first, seems to be generally orable. Dr. C. A. Arnold has called attention, how-r, to the possibility of a conflicting interpretation arding the later-homonym rule (Art. 61), if the ginal wording should be adopted. The writer relied efly on Article 61 to avoid any displacement of fossil-nt names by inadvertence, such as those instances to ich E. L. Little (*Wash. Acad. Sci. J.*, 1943, 33, 8–11, 0–135) called attention and renamed as later homonyms fossils. Consideration of this, and other constructive ggestions by Drs. W. H. Camp and Theodor Just, ds me to suggest alteration of the wording as origi-lly proposed and the addition of a note, to be inserted der Article 18 in the Rules of Botanical Nomenclature as a part of Appendix I, "Regulations for Determining pes," and to read as follows:

Names based on types derived from modern material ays take nomenclatural precedence over names based fossil or subfossil specimens, if the groups are con-neric.

NOTE: *Names based on fossil types cannot be used ain for modern plants in violation of the rule excluding er homonyms* (see Art. 61).

The effects of adopting the present proposal—in the me sense that it is now reworded—were discussed in e writer's previous note (*Science*, April 2) with refer-ce to *Metasequoia* and a few similar nomenclatural amples. Since that time Drs. Hu and Cheng have blished the name *Metasequoia glytostroboides* for the ing species (*Fan Mem. Inst. Biol. Bull.*, 1948, 1, 3–161). It is of interest, therefore, to re-examine the menclatural situation as of the present date.

According to the existing regulation, the type species f the genus *Metasequoia* Miki is *Sequoia disticha* Heer (*K. Svenska Vetensk.-Akad. Handl.*, 1876, 14, 63), and me one of the specimens illustrated by Heer might be garded as the ultimate holotype. In instances of this rt, according to the new proposal, names based on odern types would always take precedence. Therefore, *M. glytostroboides* Hu and Cheng would become the type ecies, with its type specimen (holotype), as cited by u and Cheng, "C. J. Hsueh No. 5, in flowers and ones" (February 20, 1946), and the additional reference heets taken in different developmental stages from the me tree. The inherent great advantage in utilizing is modern type material for reference in identification, over any fossil type illustrated by Heer, is obvious.

In my estimation some question still remains whether the living species is best named as "*Metasequoia.*" If the living species is the type of the genus, as it would be under the new proposal, the genus apparently should be cited for type reference as *Metasequoia* Hu and Cheng, *non* Miki.

Unrelated to the above proposal, but pertinent to *Metasequoia*, the writer also wishes to record that, through the generosity of Dr. Just, a copy of S. Miki's rare publication ("On the change of flora in eastern Asia since Tertiary period (1). The clay or lignite beds flora in Japan with special reference to the *Pinus trifolia* beds in central Hondo." *Jap. J. Bot.*, 1941, 11, 237–303) is available for consultation by American paleobotanists at the paleobotanical library of the U. S. Geological Survey in Washington.

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A Point Regarding 2,4-D Penetration

In the article by C. L. Hamner and Kiang Chi-Kien (*Science*, May 28, pp. 572–573) the statement is made that possibly Geon 31X latex may act by sealing in the *vapors* of the salt of 2,4-D. To my knowledge there are no vapors of 2,4-D (granted some slight odor from a bottle of pure 2,4-D), and especially would this be true of the salt, although in the plant this may be converted back to the acid to some extent. The m. p. of the salt is about 225° C (melting block determination of prepared salt), whereas the acid melts at 138° C. Therefore, the vapor pressure is low at normal temperatures. Since the solutions of 2,4-D are usually extremely dilute (less than a gamma/cc), it would be assumed that any effect due to the vapor pressure of the salt would be ruled out.

The probable explanation lies in the fact that by decreasing the local evaporation of moisture, Geon 31X may cause better entry of 2,4-D in solution. One might have suspected that a decrease in the gas exchange—if this is what Geon 31X does—would interfere with the photosynthetic and respiratory metabolism, but the authors report no effect of the Geon 31X when applied alone.

In general it might be surmised that anything which normally either decreases the concentration of 2,4-D or prevents its effective entry is partly or wholly prevented by Geon 31X. The observations reported are interesting and may prove of value from both a practical and a theoretical mechanistic point of view.

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Significance of Clearance Variations in the Rat

While I am very much interested by the attempt of S. E. Dicker (*Science*, July 2, p. 12) to reconcile some of the different results for glomerular filtration rate in the rat, there are several additional factors to remember which negate the reconciliation.

There is some evidence from other authors that diet protein has little effect in raising the serum protein concentration. But it is well known that an increase in dietary protein both increases renal plasma flow (Van Slyke, Hiller, Rhoads, Hiller, and Alving. *Amer. J. Physiol.*, 1934, 109, 336) and renal size (MacKay and MacKay. *J. Nutrition*, 1931, 3, 375). These factors tending to increase the glomerular filtration rate must also be considered in estimating the effect of diet.

Most authors have expressed the clearance measurements in terms of body size (cc/unit wt/unit time). Since renal size in the rat has been shown to vary not directly with body size but as a power of body size (MacKay and MacKay. *Amer. J. Physiol.*, 1927, 83, 196), differences may enter as a consequence of the relative size of the kidney in rats of widely different weight ranges.

Finally, it may be stated that different methods of clearance determinations in the same hands may give widely varying results in the rat, depending upon the precise conditions of measurement (Lippman. *Amer. J. Physiol.*, 1948, 152, 27). Determinations were made upon rats receiving nearly the same dietary protein concentration (17%) as one of Dicker's groups. If reduced to the same terms by calculation, Dicker obtained a value of 0.64 cc/gm kidney wt/min, whereas this author will report a value of 1.15 cc/gm kidney wt/min.

While it is not my intention to minimize the error that may undoubtedly be introduced into renal clearance measurements through variations in the diet, it seems to me that the precise conditions of measurement are at least of equal importance, and probably of greater importance, in explaining the differing results obtained.

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Record of the Occurrence of *Physoderma graminis* in Canada

Agropyron repens L. plants in the neighborhood of Central Experimental Farm, Ottawa, were found to be parasitized by the chytrid *Physoderma graminis* (Büsgen). The diseased plants showed dwarfing due to suppressed culm elongation and also the presence of yellowish to brown stripes. The stiff erect leaves and general yellowish appearance make these plants conspicuous in the field under close-mown conditions.

Physoderma graminis, though well known in Europe on several grass hosts, is known only from Wisconsin (United States) in North America, being recorded by Thirumalachar and Dickson (*Phytopathology*, 1947, 37, 885–888). The present record of its occurrence in Ottawa, Canada, indicates a rather widespread occurrence of the disease. The diseased plants are easily overlooked in the field, since they are overgrown by the neighboring healthy plants.

Though quack grass is not of economic importance, the possible spread of *Physoderma graminis* to other important grass hosts needs to be watched and studied. Few cases of its occurrence on *Dactylis glomerata* L. have been noticed by Dr. J. G. Dickson near Madison, Wisconsin. In Europe it is reported on several grass h of economic importance.

The writer wishes to acknowledge his indebtedness Dr. T. M. Stevenson, Forage Crop Division, for his operation, valuable suggestions, and kind interest.

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Fisheries Statistics and the Past Oyster Product of the Gulf Coast of the United States

Most Gulf States do not collect adequate data on t fisheries production, and those that do have only d so for a few years. The State of Louisiana has recor its oyster production for many years. Fisheries prod tion data are important to fisheries biologists, stude of economics, business concerns, legislative bodies, a others, and the lack of them is a deplorable gap in knowledge of past conditions of the Gulf Coast fisheri The same remarks apply to some extent to other pa of the United States. The deficiency in state producti statistics has been partly filled by the U. S. Wildl Service and its predecessors, the Bureau of Fisheries a the U. S. Fish Commission. Their statistics are co parable from state to state and, to a lesser extent, fr year to year. Here again there are great gaps, and s tistics on the Gulf Coast fisheries are available for o 24 of the years between 1880 and 1945, or slightly m than one-third of the period. These blank spaces ex because Congress was not foresighted enough to alloca funds for collection of statistics by the Federal fishe agencies. The process still goes on, and Radcliffe (Oys Institute of North America, Vol. 14, Bull. 4, p. 2, Aug 17, 1948; mimeographed) has recently pointed out th while $1,000,000 was appropriated under the Farrington Act for the study of fisheries in the mid-Pacific, due the lack of some $20,000 a year the Fish and Wildli Service cannot gather adequate production figures on t marine fisheries of the continental United States. Wh such anomalies as this arise, we may well question t wisdom of Congress or the Bureau of the Budget, possibly both.

In discussing the present oyster situation, oyster biol gists and conservationists are given to pointing to t huge production of the past and comparing it with dism to present production. For various reasons this pictu is too often correct. Nevertheless, it is exaggerated b cause of a quirk in the Federal oyster statistics, as th are published. As stated above, the Federal statisti are the only ones available for all Gulf States. Oyste men have always reported their catches in gallons, bush els, or barrels. However, the Federal statistics are give in pounds, and evidently the statistics collectors used factor to translate bushels of oysters to pounds of oyster

Fiedler *Fishery Industries of the United States, 19* Appendix II, Report of Commissioner of Fisheries, Bu reau of Fisheries, 1932, pp. 97–440) stated that in th Federal series of reports (*Fishery Industries of th United States*) in all years previous to 1931 all oyste

computed on the basis of 7.0 lbs of meat to the
l. However, the factor was determined or redeter-
l that year and found to vary from 3.23 for Ala-
oysters to 4.65 for Texas oysters. Since then, the
al reports generally give this computing factor for
state for the years reported, because the factor also
from year to year for each state. For the State
uisiana it varied from 4.09 to 5.59 in the 5 years
ted between 1932 and 1940, averaging 4.57 lbs to
ushel. This means that the Federal statistics for
tate of Louisiana, in pounds, are approximately 35%
erated for all years previous to 1931. It explains
Louisiana's oyster production in pounds, as given in
ederal reports, shows a much greater variance from
State of Louisiana barrel figures before 1930 than
wards. However, when the proper computing figures
sed for turning the Federal figures into barrels pro-
l, it is found that the annual oyster production of
siana, as given by the State and Federal Govern-
s from 1911 to 1945 for the 16 comparable years in
period, differs only by 20,181 barrels or approxi-
ly 3%, the Federal figure being the greater.

cording to the pounds figures of the Federal Govern-
, the State of Louisiana produced 10 times as much
rs in 1911 as in the lowest depression year, 1932.
ssibly this situation is the cause for misgivings con-
ng Louisiana's oyster industry, viz. Chipman (Oyster
tute of North America Trade Report No. 91, June
; mimeographed): ". . . the mortality of oysters in
siana waters threatens the very existence of the large
r industry of that state." However, the misgivings
nfounded, for the State of Louisiana statistics and
erly interpreted Federal statistics show that there
been no major decline in Louisiana's oyster pro-
ion since 1905, when the industry got under way.
mplete analysis will be given elsewhere.

nfortunately, the same thing cannot be said of other
States. Taken together, they produced 952,000 bar-
of oysters a year in the 1920s, 395,000 in the '30s,
209,000 in the '40s. This decline is clear, indubi-
, and huge.

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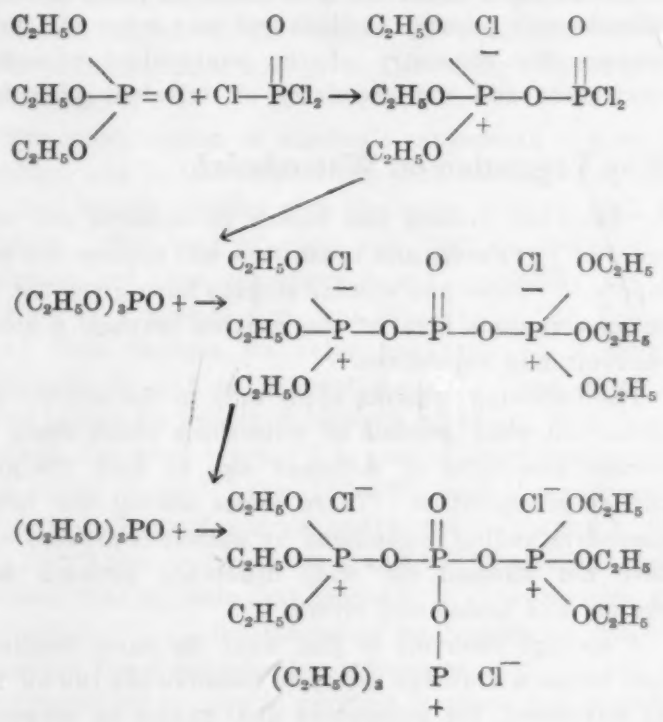
e Views on the Phosphorylation Reactions

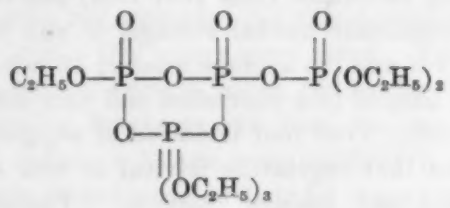
lthough several years have passed since the introduc-
of polyphosphate esters as insecticides, no investi-
ons have been made public in which the nature of
products or the mode of their formation from phos-
rus oxychloride and, for example, triethyl phosphate
been studied. The patents under which these com-
nds were disclosed (Ger. 720,577 and U.S. 2,336,302;
. G. Farbenindustrie) represent the reaction of forma-
of "hexaethyl tetraphosphate" as substitution of
rine atoms by diethylphosphoryl groups, giving the
product a symmetrical pyramidal structure.

eterminations of molecular weights of reaction prod-
of three moles of triethyl phosphate with one mole
of phosphorus oxychloride in accordance with the patent disclosures showed that the actual molecular weights range from 560 to over 700 (freezing point, in benzene); that is to say, they are considerably in excess of the theoretical value (506) required by the pyramidal formulation. In addition, the infrared absorption spectra of such products reveal a close similarity to the spectra of ethyl metaphosphate esters, characterized by a wide and intense band near 10 μ.

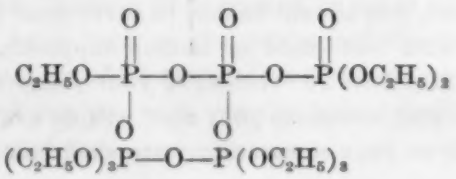
Correlation of these observations with the known hydrogen bonding tendency of trialkyl phosphates, as shown by Audrieth and Steinman (*J. Amer. chem. Soc.*, 1941, 63, 2115), leads to the possibility of the following representation of the nature of the reaction and of the resulting products, on the basis of addition reactions to the PO bond of the triethyl phosphate, giving intermediate "phosphonium type" adducts, which are capable, at each step, of formation of linear polyesters or of cyclic polyesters by thermal decomposition analogous to that of the thermal cleavage of true phosphonium compounds. The complexity of possibilities at each step merely confirms the complex nature of the final product.



It will be noted that the intermediates can decompose either "intragroup" (losing ethyl chloride) or they can react with a group in another part of the molecule by an "intergroup" reaction. Carrying the scheme to its logical conclusion, one arrives at structures shown below:



and



The formation of such high-molecular-weight cyclic compounds explains both the high molecular weights observed for such products and the type of infrared spectra exhibited by them. Even larger molecules can be visualized by extending the above representation further. In addition, a similar formulation serves to explain the formation of apparently identical substances by the interaction of phosphorus pentoxide with triethyl phosphate (Adler and Woodstock. *Chem. Industr.*, 1942, 516).

The concept of addition reactions to the PO linkage has been mentioned by Gerrard (*J. chem. Soc.*, 1945, 106) as a possible mode of reaction of alcohols with phosphorus oxychloride, through an intermediate adduct of a type ROH . . . $OPCl_3$. It is possible, however, to modify this concept and to formulate such a reaction by means of a "phosphonium type" mechanism similar to that used above.

Such a formulation, in so far as known, is not contrary to known facts about the interaction of phosphorus oxychloride with primary alcohols and may serve as a bridge between the chemistry of the pentavalent phosphorus compounds and the chemistry of trivalent phosphorus compounds, where the formation of "phosphonium t adducts has been observed in numerous cases. The formation of an adduct between an alcohol and phorus oxychloride has been shown by the determi of molecular weights of equimolecular mixtures of tanol and phosphorus oxychloride in benzene at 3 Within 5 min of addition the average molecular w was found to be 186.3; 1 hr later the value rose to indicating a slow and steady accumulation of an a After 1 hr the mixture began to evolve hydrogen chl (which may be formulated as given above), and the of the average molecular weight obviously began to This appears to be the first instance of detection adduct of an alcohol with phosphorus oxychloride. tempts to use alcohols of lower molecular weights

$$R{-}O{-}H + O{:}\,PCl_3 \rightarrow R{-}O{-}\overset{H{-}O}{\underset{}{P}}{-}\overset{+}{Cl}\,\overset{-}{Cl}{-}Cl \rightarrow R{-}O{-}\overset{O}{\overset{\|}{P}}Cl_2 + HCl$$

mixtures in which the evolution of hydrogen chl began at much lower temperatures, such as to pre reliable measurements with conventional solvents.

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Why Vegetation on Watersheds?

"Save our forests and humus to conserve our water supply." "Forest and brush fires will deplete our water supply." These and similar slogans have given the public an erroneous idea of the relation between a storage reservoir and vegetation.

The following remarks apply only to the strictly utilitarian but vital problem of watersheds which drain into *storage* reservoirs of sufficient size to hold the entire annual precipitation. There exists among the laity a misunderstanding engendered by numerous articles which have not stressed the wide difference between water *storage* and undammed rivers.

A storage reservoir is just what its name implies—a dam across a drainage artery to conserve the run-off from its watershed, for subsequent distribution to consumers. Is vegetation on such a watershed of value in the sense in which it is ordinarily understood, or is its chief value altogether different?

If you lived in southern California, or in a location with similarly distributed rainfall, and had a large cistern for catching rainwater from your roof, you could estimate your approximate annual storage, if you knew the area of your roof and the average amount of rainfall. Your roof may be likened to a watershed and your cistern to a storage reservoir. Your roof is devoid of vegetation, but you understand that vegetation is vital to your community's watershed and storage reservoir. Therefore, if you are consistent, you should hasten to cover your roof with boxes filled with leaf mold or humus supporting a luxuriant growth of plants to "conserve your water supply." The plants and humus on your roof will do exactly what they would do on your community watershed, namely, catch and hold part of the water that would have into your cistern. The luxuriant plants gradually a much of it and breathe it out into the atmosphere. remainder evaporates from the surface of the h except for a little which has been delayed and grad seeps out of the boxes, but most of this seepage evap before reaching your cistern.

Looked at in this light, it is evident that vegetati a watershed draining into a storage reservoir cau waste of water. The evaporation from the surfa the impounded lake is but a fraction of the loss sust by the evaporation from vegetation and from the layed" water which gradually seeps toward the reser but is largely lost by capillarity and the ensuing eva tion. Therefore, vegetation on a watershed is a d ment in so far as saving all the water that falls is cerned.

As one sails among the West Indies, or other p that suffer from protracted droughts, one notes white areas on the hillsides above the towns. These water-catching areas that drain into reservoirs. authorities would no more think of covering them vegetation than you would your roof from which yo pected to fill your cistern. How do these catchment a differ from the watershed of your community? The areas are solid cement pavement—very rough, unador and purely utilitarian, but very effective.

Now we come to the real and vital need for vegeta on our watersheds. It is purely mechanical. If the erosion, the reservoir will *fill* with detritus and you be without storage *space*. If you could have your w shed covered by "gunnite" or paved, you could re all but a negligible fraction of the rainfall. There the only use of vegetation on your watershed is to

e soil in place and prevent it from filling your reser-
r. The holding back of rainfall by vegetation and
us is wasteful of water.

The watershed of an undammed river is a different
position, since it is desirable to delay the water as
h as possible so that it will not rush to the ocean. In this case, it is the *delayed* water that interests us. The far greater portion of it that is evaporated by the vegetation is the price we gladly pay to insure a small but steady flow in the valley.

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Book Reviews

rowave transmission circuits. (Massachusetts Insti-
ute of Technology Radiation Laboratory Series.) George L. Ragan. (Ed.) New York-Toronto-London: McGraw-Hill, 1948. Pp. xvii + 725. (Illustrated.) 8.50.

This is one of a set of 28 volumes forming the Radia-
n Laboratory Series, in which information previously ilable only in classified reports, or in many cases un-
blished information, is recorded. Most of the material cerns techniques evolved during the war in the develop-
nt of microwave radar.

The term *microwave* designates radio waves roughly in
range of wave lengths between 1 and 30 cm. As se wave lengths are of the same order as the dimen-
ns of the various circuit components, new problems se which are not present at lower frequencies. The ve aspects of electromagnetism become of increased im-
rtance, whereas the electric currents are of less impor-
ce and the concept of *voltage* is generally ambiguous. In common with low-frequency circuits, the microwave tems can generally be divided into three parts, gen-
tors, receivers, and interconnecting elements. The k under discussion concerns itself solely with the in-
connecting elements. In a microwave circuit these ments consist of transmission lines of various types and ctions between these transmission lines. Engineering blems connected with these circuit elements are exten-
ely treated. Included are coaxial and wave guide nsmission lines, both rigid and flexible. Power divid-
, tuners, couplings, and switches may be mentioned as mples of transmission line junctions. There is a sec-
n on microwave filters and an introductory chapter on e theory of the transmission line.

Although 7 authors contributed to the book, it is well ganized and has little overlap. It is reasonably com-
ete. A description of the magic tee and its various es, such as power divider, tuner, and line stretcher, ems, however, to be missing. The book is valuable gely because of the engineering data which it contains.

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gher algebra: a sequel to "Higher algebra for schools." W. L. Ferrar. Oxford, Engl.: Clarendon Press; New York: Oxford Univ. Press, 1948. Pp. vii + 320. $5.00.

Although this book is a sequel to *Higher algebra for hools*, it is not written so that the earlier book is the ly source of the needed preliminary knowledge. The terial is planned for study in "top mathematical rms in schools and first year classes in universities." here are discussions of series, complex numbers, difference equations, theory of equations, partial fractions, inequalities, and continued fractions. There is no general discussion of convergence and divergence, the summing of finite and infinite series being stressed. A lucid introduction to complex numbers uses directed number, or vector, as the basic definition. Thus, Demoivre's theorem is readily obtained and is used in the next chapter to yield many trigonometric identities; bilinear transformations are another application of complex numbers. The relations between the coefficients of an equation and the symmetric functions of its roots, and the exact solutions of a cubic and a quartic, are the principal topics in the theory of equations. Several general inequalities are given, including Hölder's and Minkowski's.

The manipulation of algebraic expressions is a central feature, and in this respect the work has the same spirit as that classic treatise with the same title by Hall and Knight. The level of rigor can best be indicated by pointing out that convergence and continuity are not defined in a precise way, but intuitively: "A function $f(x)$ that changes its value gradually as x changes gradually is said to be continuous." Thus, many results cannot be proved rigorously, although, surprisingly enough, the word "proof" is used without qualification, e.g. in the "proof" (pp. 135–136) that if a polynomial $f(x)$ is positive for $x = a$ and negative for $x = b$, then $f(x) = 0$ has a root between a and b. The author makes it clear that he feels that precision in these matters may well wait: ". . . the intending mathematician must be prepared for a considerable refinement . . . ."; and yet he expects his readers to perform intricate and ingenious manipulation with some very difficult problems. But if students are not benumbed by these problems, they are surely ready for some critical mathematics. In addition to this criticism, the absence of determinants will restrict the usefulness of the book as a text on this continent. Most Canadian and American college students are, of course, not prepared for this material in their first year.

Only a few errors were noted. For example, multiplication by zero is never defined in the development of complex numbers; the fact that an algebraic equation of degree n in the complex field is solvable and has n roots is not even stated, let alone proved, but is used; and Theorem 38 is needed in proof of Theorem 37.

As a book in the celebrated English tradition of elementary mathematical texts, placing great emphasis upon, and replete with, manipulative problems, the volume is a success.

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Scientific Book Register

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DEROBERTIS, E. D. P., NOWINSKI, W. W., and SAEZ, FRANCISCO A. *General cytology.* (Trans. by Warren Andrew.) Philadelphia-London: W. B. Saunders, 1948. Pp. xi + 345. $5.50.

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HEVESY, GEORGE. *Radioactive indicators: their application in biochemistry, animal physiology, and pathology.* New York-London: Interscience, 1948. Pp. xvi + 556. (Illustrated.) $10.00.

HOWE, HARLEY. *Introduction to physics.* (2nd ed.) New York-London: McGraw-Hill, 1948. Pp. xii + 599. (Illustrated.) $4.50.

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OLSON, AXEL R., ORLEMANN, EDWIN F., and Koc CHARLES W. *Introductory quantitative analysis.* Francisco, Calif.: W. H. Freeman, 1948. Pp. viii + 2 (Illustrated.) $3.25.

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USPENSKY, J. V. *Theory of equations.* New York-Lo don: McGraw-Hill, 1948. Pp. vii + 353. $4.50.

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